Ontario
Ministry
of
Housing
Chaviva Hosek, Minister

EVALUATION OF EXTERIOR INSULATION CEMENTITIOUS FIBRE-REINFORCED CLADDING SYSTEM (EICFS)

FEBRUARY, 1989

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EXTERIOR INSULATION CEMENTITIOUS FIBRE-REINFORCED CLADDING SYSTEMS

PREPARED
FOR

THE ONTARIO MINISTRY OF HOUSING

by

TROW INCORPORATED
CONSULTING ENGINEERS

FEBRUARY 1989

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Section 3, Glass Fibre Reinforced Cement Composite (GFRCC) Systems, was contributed by Professor John Timusk of the University of Toronto.

Professor Eric Burnett of the University of Waterloo was instrumental in defining the subject area and in providing initial guidance to the project.

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PURPOSE AND SCOPE

This document endeavours to present a review of the performance characteristics and practices relating to Exterior Insulation Cementitious Fibre Reinforced Cladding Systems (EICFS) as currently used in Canada and the USA. It deals with most of the significant aspects of the subject, but does not represent the final word on these systems, nor does it deal with all of the possibilities and problems involved in this rapidly growing system of exterior cladding.

It outlines the principles which should be considered by the architects and engineers involved in the design and field inspection of buildings using the EICFS systems, and offers suggestions as to measures that will provide optimum performance and extended service life.

Suggested specifications and inspection check-lists for both factory manufactured panels and field applied systems are provided as indicative of current practice.

An explanatory paper on the characteristics and performance of Glass Fibre Reinforced Cement Composite Systems offers a basis for further understanding and development.

The document is of necessity generic in the treatment of the subject and special features of specific systems involving unique material formulations, structural designs, and application techniques offer differences in performance and cost on which only the individual proponent can comment in detail.

Comments and criticisms of any aspect of the document are welcomed. These may be addressed to the Ministry or to the Consultants at the following locations :

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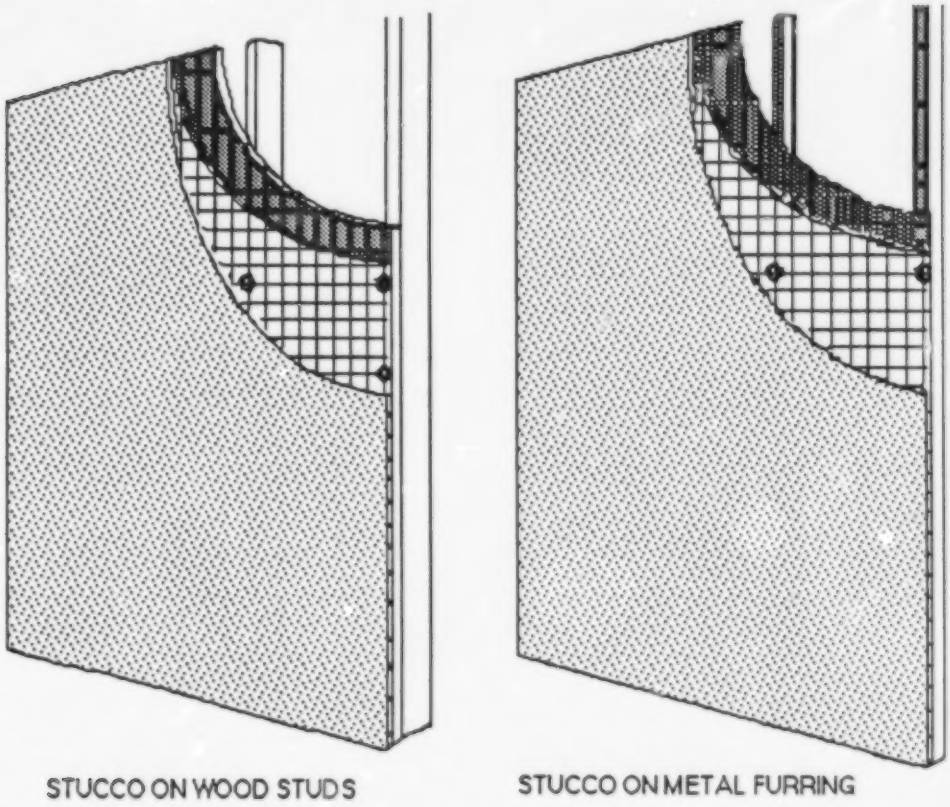
SECTION 1
EICFS SYSTEMS

BACKGROUND

Cement-based, field-applied exterior finishes have a long history in North America and Europe. In Europe, application has usually been as a "rendering" on masonry substrates while in Canada "stucco" is commonly applied to wood frame construction, or to metal furring on commercial buildings.

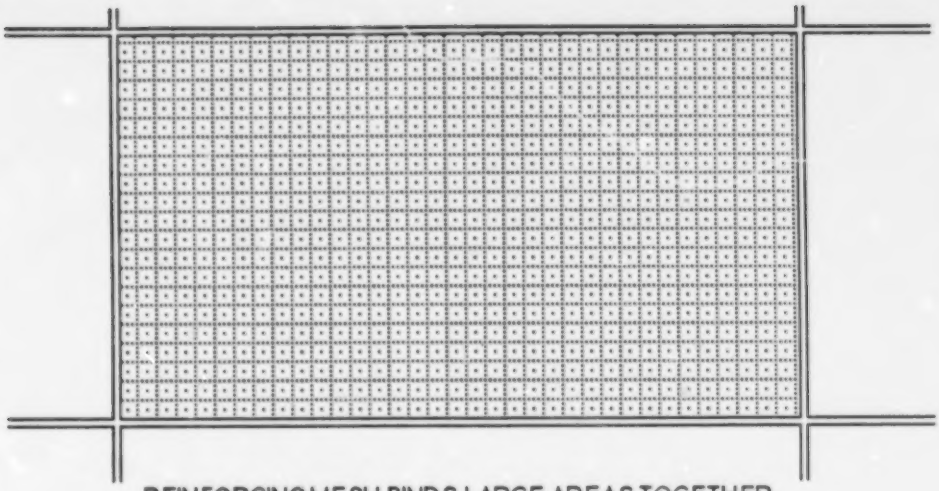


STUCCO ON WOOD STUDS

STUCCO ON METAL FURRING

FIGURE 1

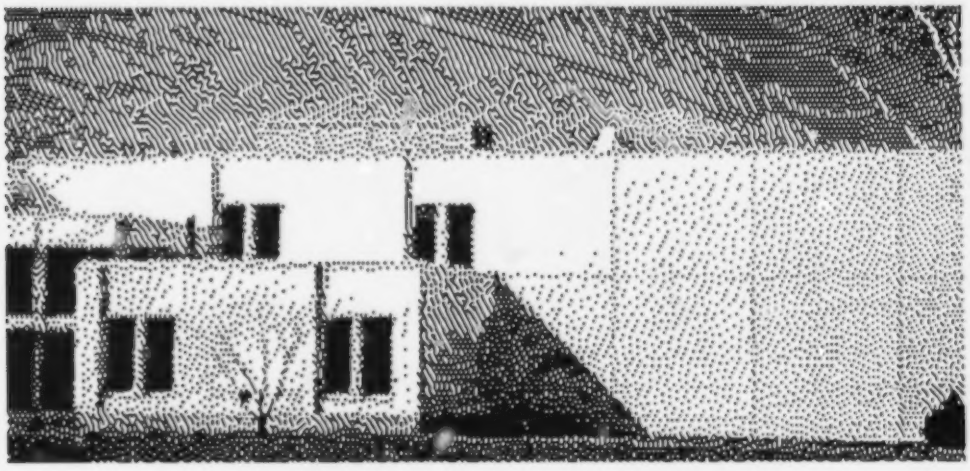
Traditionally, metal mesh "reinforcement" is employed to achieve attachment to the substrate and to distribute any induced tensile stresses. For the unbroken cladding areas associated with small buildings this promotes uniform, "hairline" tensile cracks to occur throughout the stucco, rather than fewer, wider and more noticeable cracks at unpredictable locations.



REINFORCING MESH BINDS LARGE AREAS TOGETHER

FIGURE 2

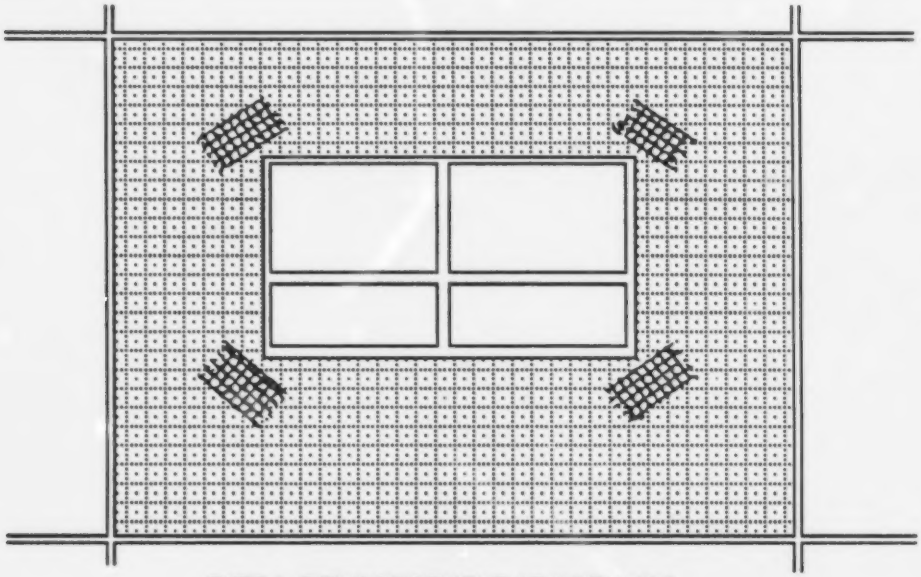
For larger or longer cladding areas, the reinforcement provides the finish with the tensile strength to allow shrinkage to be concentrated at intentional movement joints strategically located in the exterior cladding. These joints are designed to accomodate the movement, to exclude rain, and to appear as an integral part of the cladding arrangement.



JOINTS INTEGRATED INTO BUILDING FEATURES

FIGURE 3

Additional reinforcement is usually provided at points of stress concentration such as at the corners of window and door openings and at the edges of the exterior façade (1, 2).



EXTRA REINFORCEMENT AT OPENINGS

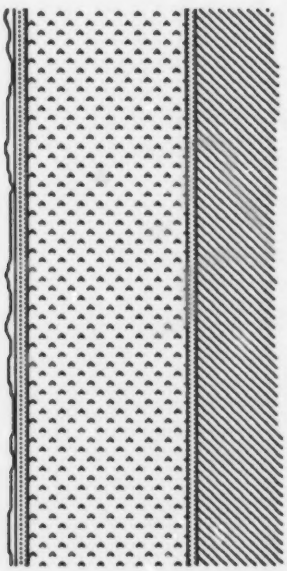
FIGURE 4

Stucco as an exterior cladding on insulated metal stud walls in commercial construction was introduced by an enterprising contractor in Western Canada in the late 1960's. Gypsum board sheathing was installed with metal purlins providing an air space behind paper-backed metal lath, to which the stucco was applied. Friction-fit glass-fibre insulation was installed between the studs, with polyethylene film as a vapour barrier and gypsum board interior finish. The gypsum board was taped to the bounding concrete slabs at floor and ceiling levels to provide continuity in the air barrier. The void behind the stucco was treated as a drained and vented space in keeping with the open rain-screen principles of the time. A similar system was employed on a concrete block masonry building in Ottawa, utilizing the steel studs as an exterior, insulated furring support for stucco cladding.

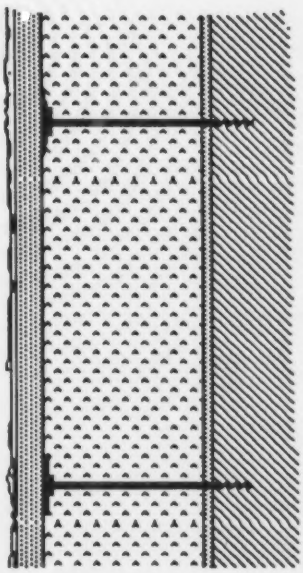
Thinner renderings incorporating synthetic polymers and glass fiber reinforcement, originated in Europe. They have been introduced to North America over the last 25 years. Initially, some were applied indiscriminately to a variety of existing substrates without additional reinforcement or surface preparation and with mixed results. Subsequent advances in the technology of polymer-modified and glass-fibre reinforced cement mortars have resulted in the development of systems utilizing such coatings applied to exterior insulation as cladding systems for new or retrofit construction.

These systems have experienced problems when applicators have not followed the manufacturers mixing and application recommendations. There have also been cases where cracking has occured at the corners of window openings or other locations of stress concentration. This cracking has usually been overcome by the inclusion of additional mesh reinforcing at such locations.

There are two basic approaches used in the application of these exterior insulation systems.



COMPONENTS SECURED TO SUBSTRATE BY ADHESION



COMPONENTS SECURED WITH MECHANICAL FASTENERS

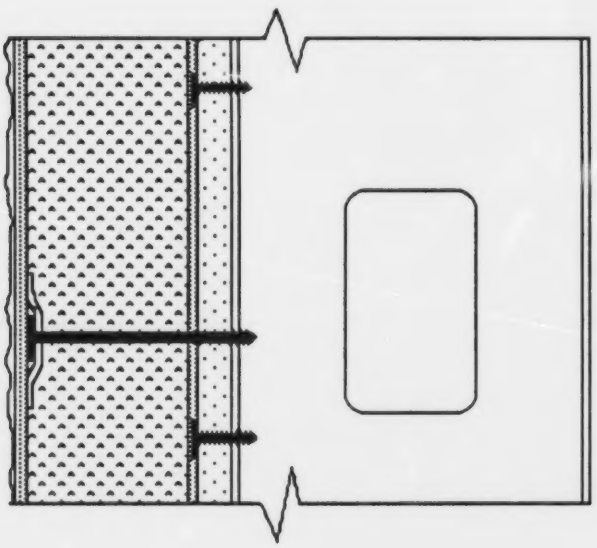
FIGURE 5

One approach relies entirely on specially formulated and applied adhesives to secure expanded polystyrene insulation to the structural substrate, and to secure the stucco and glass fabric reinforcing to the insulation.

The other system utilizes mechanical fasteners in addition to interface materials to secure extruded or expanded polystyrene insulation to the structural substrate, as well as mechanical fasteners to anchor the glass fabric reinforcing and stucco to the structure. Some systems utilize chopped glass fiber additions to the stucco to provide additional strength and toughness to the finish.

The exterior insulation approach has become popular as a means to improve the thermal performance of masonry walls and to replace and protect deteriorated masonry facades. The exterior insulation/stucco systems are percieved as allowing more flexibility in appearance than insulated metal furring/metal cladding systems. All systems require special consideration of the substrate condition for attachment.

The most popular approach for new construction in Canada involves the use of metal studs supporting gypsum board sheathing as the substrate. The system is adaptable to both field erection and application and to panelized factory production.

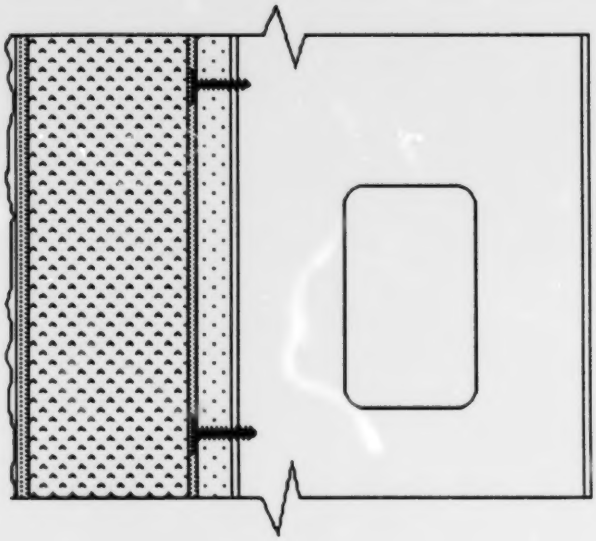


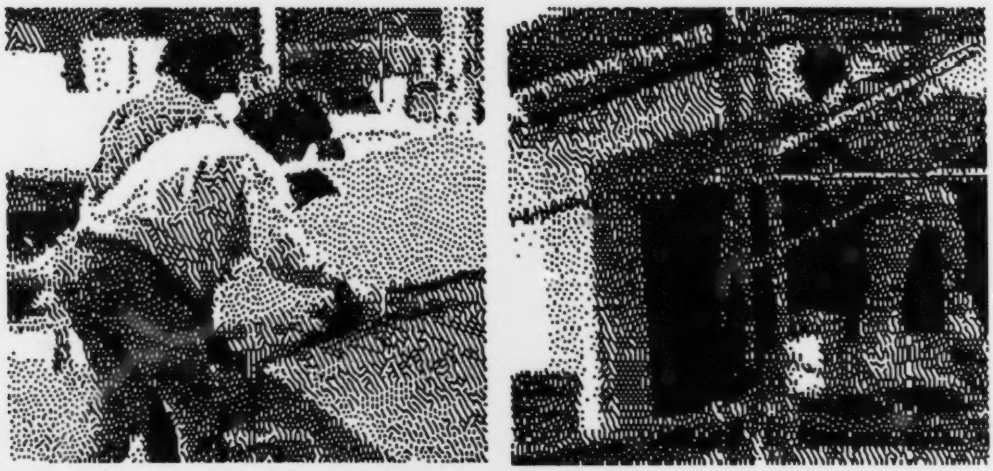
MECHANICAL FASTENING TO METAL STUDS

FIGURE 6

ADHESION TO SHEATHING ONLY

FIGURE 7





FACTORY APPPLICATION

FIELD APPLICATION

FIGURE 8

In panelized factory production, the steel framing members are welded together and the stucco application is carried out on horizontal surfaces. Although factory fabrication conditions can be more closely controlled, damage to the finished panels in transit and erection is a concern.

IMPACT RESISTANCE OF EXTERIOR FINISH

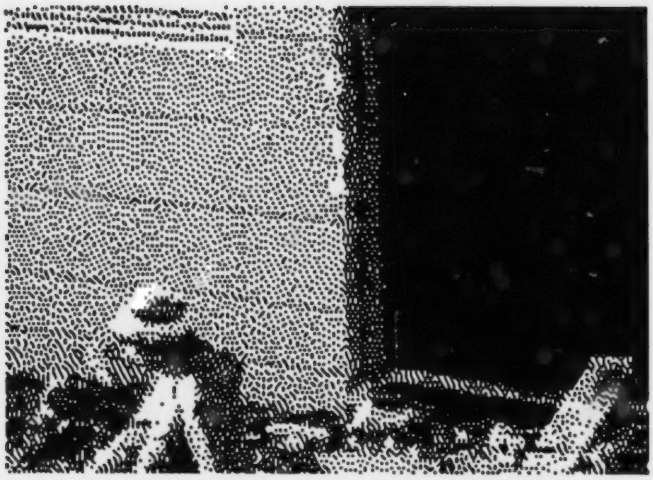
Apart from the initial problems associated with inexperience in application and mixing or storage of materials, the concerns most frequently expressed in regard to stucco cladding systems have been in relation to the impact resistance and cracking of the exterior finish (2).

The stucco coatings can be formulated to adequately resist impact loads occasioned by normal human activities surrounding a building. If necessary, improved resistance to damage can be incorporated into the coatings on the lower floors near grade level to reduce damage by vandalism in family housing projects (2, 3). If extremely rough use is anticipated, the first floor may be constructed with traditional materials such as masonry or concrete.

BRICKWORK AS FIRST FLOOR CLADDING

FIGURE 9

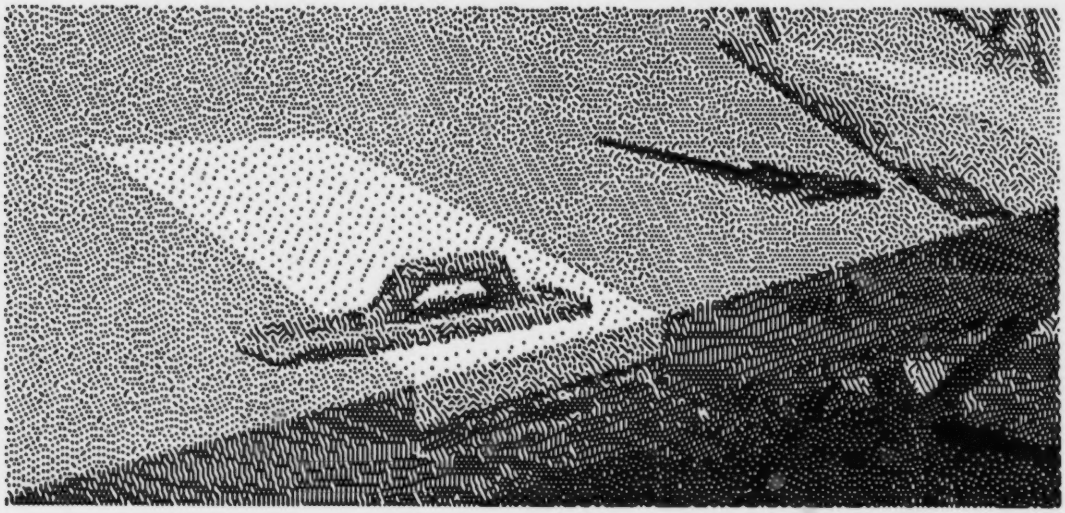
Additional protection or care may be necessary to avoid damage to panels being loaded, transported, and erected and temporary protection may be required at access areas during construction. For locations such as loading or delivery areas and doorways, corner guards, bollards, stops or other measures should be used to avoid damage to the cladding.



DAMAGE TO DOORWAY
DURING CONSTRUCTION

FIGURE 10

Minor damage suffered by the surface coating and insulation substrate can be repaired in the field and careful control of the formulation and colour of the coating allows undetectable repairs to be made. More seriously damaged panels should be returned to the original plant for repair or replacement.



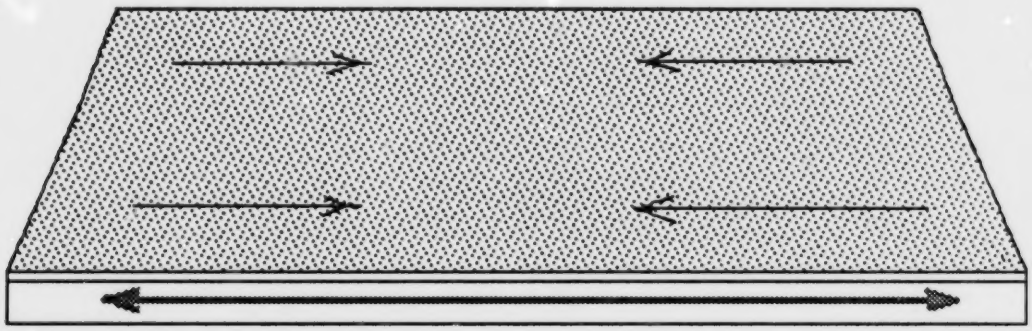
REPAIR OF PANEL IN PLANT

FIGURE 11

CRACKING OF EXTERIOR FINISH

The initial shrinkage of cementitious coatings may be as much as 0.1%. An unrestrained ten foot (three metre) wide panel could thus shrink by one tenth of an inch (3mm).

Conventional cement stucco is very weak in tension, and will fail if it is stretched beyond 0.01% or one tenth of the potential shrinkage. Thus if the panel was held to its initial size, the induced tensile strain (0.1%) could exceed the tensile breaking strain of the stucco (0.01%) and the panel would crack at its weakest point.



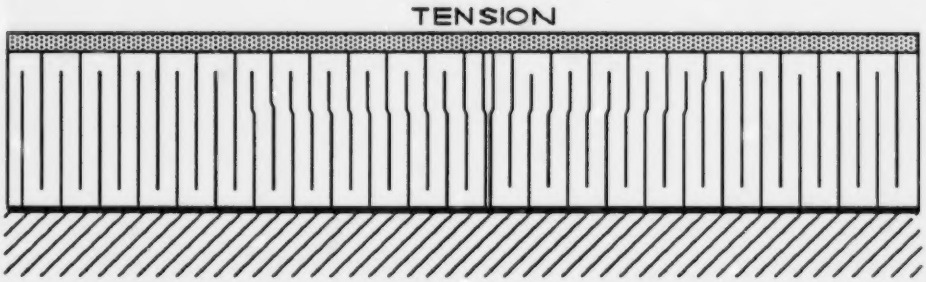
STUCCO SHRINKAGE-RESISTED BY SUBSTRATE

FIGURE 12

With the stucco bonded or keyed to the polystyrene substrate, the polystyrene will tend to resist the shrinkage and tensile forces will develop in the stucco. If the restraining force is sufficient, the stucco will crack at the point of maximum strain. The mesh or fibre reinforcement in the stucco has a much higher tensile strength than the stucco and acts to distribute the forces uniformly. Instead of one crack occurring, many small, micro-cracks tend to develop throughout the material. If such micro-cracking occurs after initial shrinkage, the stucco might be thought of as many individual pieces of stucco, securely and intimately held together by the reinforcing, and by their physical bond to the more flexible insulation.

The stucco and its substrate will subsequently be subjected to temperature changes on a daily and seasonal basis. With falling temperatures, both will tend to shrink, but the polystyrene will tend to shrink by a greater amount. The coefficient of thermal contraction and expansion for cement stucco is about 11 (x 10^{-6}/deg C) compared to 20

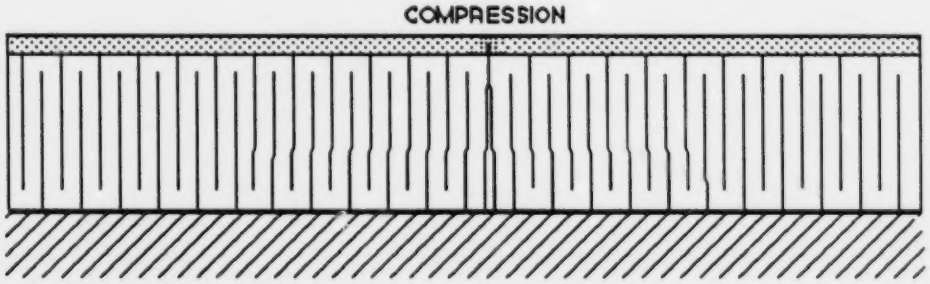
(x 10^{-6}/deg C) for expanded polystyrene and 60 (x 10^{-6}/deg C) for extruded polystyrene.



TENSION INDUCED IN COATING BY INSULATION AT LOW TEMPERATURE

FIGURE 13

Thus an unbroken polystyrene board could induce compressive forces in the stucco that is bonded to it, closing any cracks more tightly. At joints between polystyrene boards, however, it is conceivable that tensile forces will be induced in the coating, particularly if the boards and stucco were uniformly or intermittently fastened to a fixed backup.



COMPRESSION INDUCED IN COATING BY INSULATION AT HIGH TEMPERATURES

FIGURE 14

With a rise in temperature, the polystyrene will tend to expand more than the stucco, creating tension forces in the stucco over each insulation board. At the joints between insulation boards, however, the expanding boards will tend to induce compressive forces in the coating that spans the joint.

"SOFT-COAT" AND "HARD-COAT" FINISHES

The so-called "Soft Coat" systems are characterized as being thinner and having a higher concentration of glass fibre reinforcing than the so-called "Hard Coat" systems. The "Soft Coat" finishes are designed to have a greater tensile strength and ductility than the "Hard Coat" finishes. Their formulation and reinforcement increases their tensile breaking strain above that of cement stucco. Expansion and contraction joints may thus be spaced at wider intervals with such materials. This assumes that the higher tensile strength and greater ductility is maintained throughout the service life of the stucco.

A recent paper by Shah et al (4) on glass fiber reinforced concrete (GFRC) reports that, "In spite of the improved alkali resistance (of the glass fibers), long term weathering tests reveal that GFRC panels may exhibit reduced tensile strength and loss of ductility with aging." They refer to several papers advancing theories as to why this "strength regression and embrittlement of GFRC" occurs, one of which suggests that the reduction in strength is associated with microcracking due to shrinkage.

Plastic coating of the glass fiber mesh has been shown to counteract this effect and thus the action of the continuous mesh in distributing the forces due to thermal expansion and contraction should be maintained. The action of the uncoated glass fibres in providing improved ductility and strength during the initial shrinkage of the coating will still be realized before any such long term reduction in their contribution is experienced.

DESIGN OF JOINTS

Joints should be located wherever the anticipated differential movement is likely to result in a strain that exceeds the tensile breaking strain of the exterior finish. The architectural design of elevations should, therefore, recognize this possibility and locate movement joints where the maximum tensile strains are likely to occur.

- At movement joints in the substrate
- At locations where the glass fiber mesh is interrupted

With field applied coatings, the mesh reinforcing is interrupted at a control joints and the joint bridged with a pre-formed, flexible metal insert, in much the same way as is done with conventional stucco.

In panelized systems, the joints at panel edges are field-caulked with flexible sealants using materials and techniques commonly employed for joints between precast concrete cladding panels.

When flexible sealants are to be used in movement joints, the joint width should not be less than the minimum required for the proper application of the sealant that is to be used. To maintain the seal under cyclical loading, the wider joints will perform better; but practical considerations of appearance, cost of sealant and the potential for sag in wider joints should be recognized (5).

Determination of the minimum joint width for a sealant is dependent on the expected movement at the joint. This movement will depend on the coefficient of thermal expansion of the exterior finish, the maximum width between joints, and the temperature range to which it will be subjected.

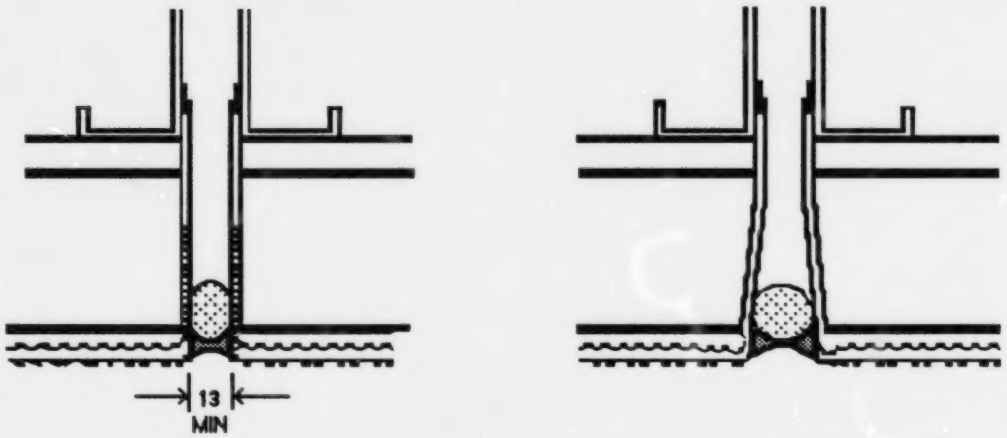
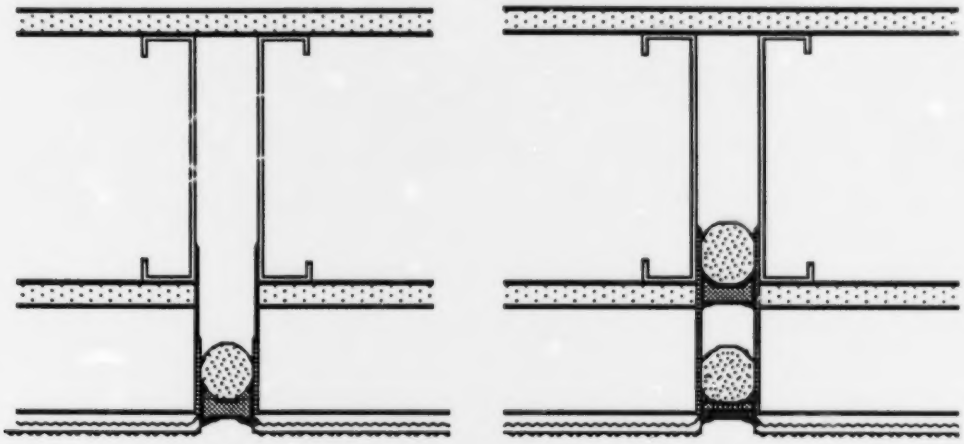


FIGURE 15

The minimum temperature likely to be experienced by the exterior finish can be approximated by the 1 percent January design temperature for the location involved. The maximum temperature experienced will be that in midsummer under sunlit conditions. This maximum value may be approximated by assuming the outdoor air temperature to be the 2 1/2% July dry-bulb design temperature for the locality, plus a value of 55 multiplied by the solar absorption coefficient. The solar absorption coefficient will vary between 0.45 for clean white surfaces to 0.95 for a black surface (8).

With a further assumption that the contraction of an expanse of exterior finish is uniform, the effective length of panel involved will be equal to half the combined width of the two adjacent panels. The coefficient of thermal contraction may be assumed as 11 x 10^{-6} / deg C (equivalent to that for Portland cement-based stucco).

For Toronto, the minimum joint width between 20 foot long (6 metre) panels would be about one-half inch (13 mm).



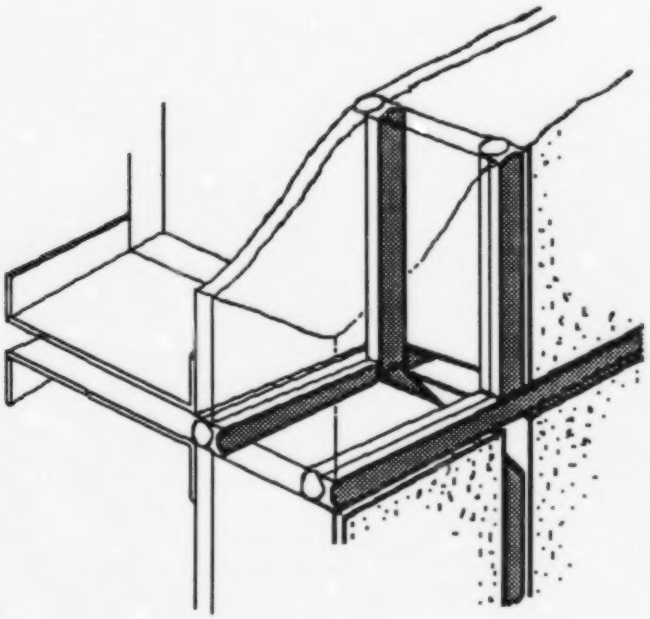
SINGLE STAGE JOINT TWO-STAGE JOINT

FIGURE 16

The joints between panels provide locations where rain penetration may occur and a two-stage seal is to be preferred over a single seal at the outer face. In the two-stage system the outer "face seal" acts solely as a deterrent to direct water entry and should be "open" to allow for pressure equalization and drainage from the space behind. The inner seal need not be airtight, but must be much tighter than the outer face seal.

To prevent rain penetration, the outer face seal is usually unnecessary. If face sealing is specified for reasons of appearance, it may not always achieve the desired result, particularly when joint width tolerances and uniformity cannot be controlled.

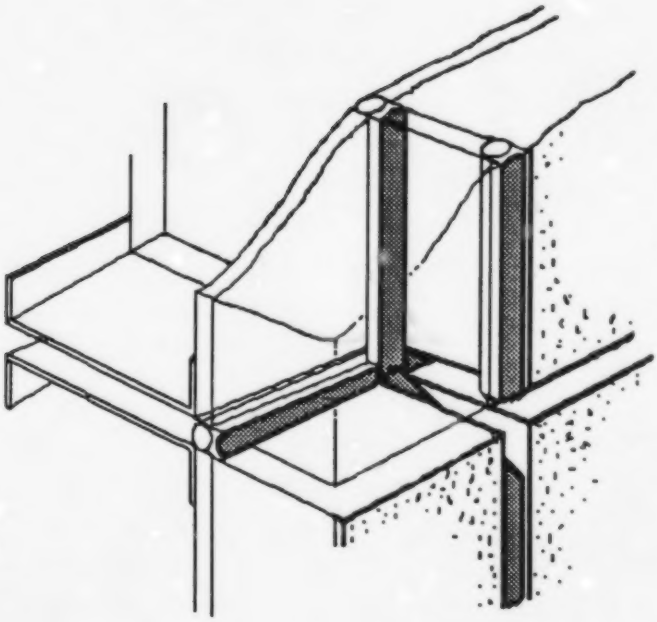
Achieving a satisfactory inner seal is more important, and while its appearance is of little consequence, it may often be difficult to install from the exterior if the joint opening is too narrow for the caulking gun nozzle or if rough textured finishes at the panel edge interfere with the process. If the inner seal can be applied at a location inward of the exterior insulation, its movement capability, its resistance to solar radiation and weathering, and its colour are much less important if not inconsequential.



TWO STAGE JOINT

HORIZONTAL JOINT
FACE SEALED

FIGURE 17



TWO STAGE JOINT

HORIZONTAL JOINT OPEN

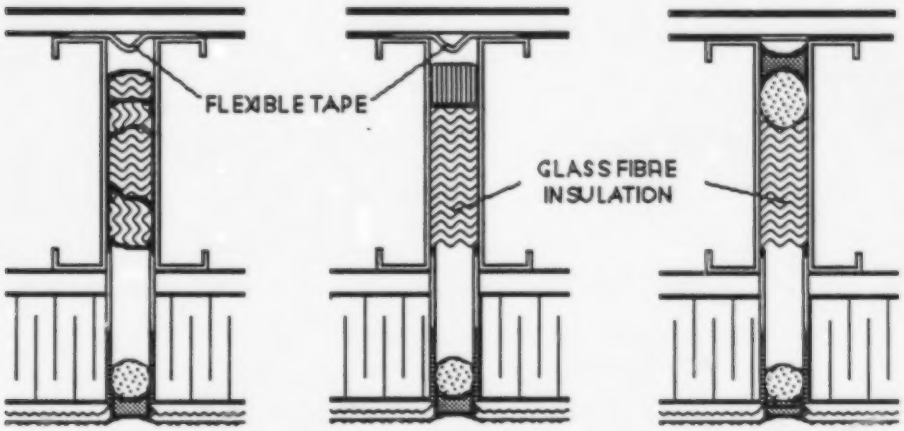
FIGURE 18

An alternative, and perhaps a more satisfactory method is to apply the inner seal from the building interior provided that there is enough clearance at the face of floor slabs, shear walls, and columns to properly apply the seal.

Three possible approaches might be considered.

- A packing of resilient glass fibre in polyethelene wrapping could be stuffed into the joint
- An impregnated open cell foam plastic could be pre-compressed and slipped into the joint
- A closed cell plastic backer rope could be used as backup for a sealant.

In all cases, a secondary air- and vapour-seal could be provided by a pressure sensitive tape applied to the face of metal perimeter framing across all joints.



ALTERNATIVE TWO-STAGE JOINTS

FIGURE 19

To fully capitalize on the two-stage joint to provide rain tightness, the outer seal should be open and drained at the base of the panel, with some form of flashing incorporated along the horizontal joint. It need be far from perfect, and some highly compressible gasket , of an aesthetically acceptable colour, might be installed to provide the deterrent to water entry, provided that it is left open to provide drainage.

ADHESIVE AND MECHANICAL FASTENING

Both hard- and soft-coat systems utilize some adhesion between coating, insulation, and substrate.

The glass fiber mesh in all systems acts as a continuous reinforcement and allows the exterior coating in which it is included, to behave as a single membrane. In fully adhered systems, the coating is tied to the substrate by the insulation boards. When mechanical fasteners are the predominant bond, the connection to the structure is the mechanical fastener.

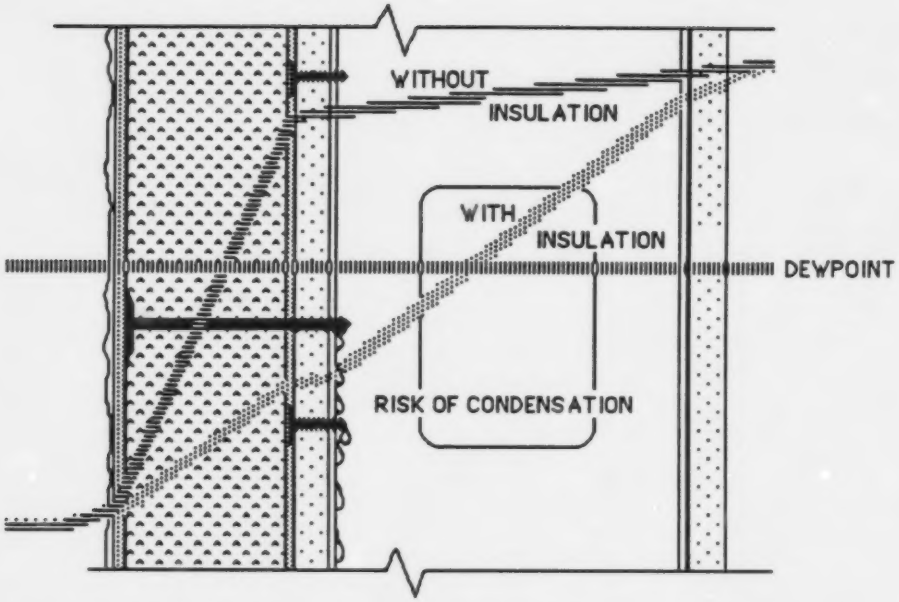
WETTING OF GYPSUM SHEATHING

Some recent reports have suggested that rain penetration to the gypsum sheathing on houses with metal or wood stud framing has resulted in extensive delamination at the insulation / gypsum board interface (6). The bond between the paper covering and gypsum as well as the strength of the gypsum will deteriorate when wet..

Moisture deterioration has been attributed to intermittent strip or dab application of the insulation adhesive and to rain penetration through cracks and joints in the exterior finish. Although the polystyrene insulation can protect the gypsum sheathing from water, if it is not fully adhered to the sheathing, rain penetrating through joints in the exterior finish and insulation could wet large areas of the sheathing from outside.

Recommendations for improved performance have included the use of a continuous adhesive coating on the sheathing, the use of more moisture resistant sheathing materials such as "wonderboard", and the use of mechanical fasteners.

The problems described are more likely due to moisture from indoors condensing on the gypsum sheathing, particularly if fibrous insulation is installed between framing members (7) Such insulation lowers the temperature of the sheathing, increasing the potential for condensation over that if no insulation was installed.



TEMPERATURE GRADIENTS WITH AND WITHOUT STUD SPACE INSULATION

FIGURE 20

Mechanical fasteners extending through the insulation provide a thermal bridge to the outer cladding. The point of connection to the metal stud will thus be colder than in systems which do not employ such fasteners, and condensation may occur at this point, even if no thermal insulation is installed between studs.

FIRE PERFORMANCE

There are several aspects to be considered in regard to the fire performance of lightweight cladding systems.

- The ignitability of the cladding as a result of a fire in an adjacent building.
- The ignitability and combustibility of the cladding as a result of fire emanating from an opening in the exterior envelope or from an external fire below the cladding
- The potential for progress of the fire upward within the cladding system.
- The heat generated by combustion of the cladding system.

Full-scale fire tests are initially required by the building officials to evaluate the first three of these performance features, but smaller scale tests are being developed (8). Estimates of the fire load contribution through combustion of the cladding may well be determined by a knowledge of the individual material properties.

Both the rate of fire propogation upward or the spatial separation required from adjacent buildings may be influenced by the exterior coating properties and thickness. The use of aggregates, such as gypsum, which contain chemically bound water could improve the fire resistance.

Currently, the Ontario Code will allow the use of these cladding systems on buildings of non-combustible classification where the area of windows, or other unprotected openings is over 25% of the area of the facade in question.

Restrictions are also placed on the maximum rate at which flames will rise above such openings and the amount of heat energy radiated under specified test conditions.

SUMMARY

In many respects the Exterior Insulation Cementitious Fibre-Reinforced Cladding Systems (EICFS) are similar to the traditional stucco cladding systems used in Canada. The plastic coated glass fibre mesh is the alternative to galvanized wire mesh, serving as continuous reinforcement within the exterior coating with intermittent bonding to the base substrate through mechanical fasteners or individual insulation boards.

Stucco applied to wood-frame construction is not bonded to its immediate substrate whereas the cementitious coating in EICFS systems is bonded to the insulation boards to varying degrees, depending on the particular system. The interactions between the insulation and coating due to the differences in their expansion and contraction properties will be complex, and may have been oversimplified in this analysis.

The expansion and contraction properties of the fibre-reinforced cementitious coatings used in the EICFS systems and their tensile strength, ductility, and impact resistance vary from those of conventional stucco to a degree that depends on the specific formulations and fibre-reinforcement used by the particular manufacturer. The general nature of the interactions due to initial shrinkage, temperature change, and moisture are likely to be similar, and can serve to explain some of the observations of past performance.

There seems to be every reason to believe that few problems will occur with EIFCS systems when they are applied by experienced applicators.in accordance with the manufacturers specifications. Surveys of existing buildings built under such circumstances over the past ten or more years in locations in the northern USA and in colder areas of Canada have indicated no significant problems. Initial experiences of cracking at window openings and at corners with some early designs, gave rise to the current requirements for additional reinforcement at these locations. Refinements and improvements are continually being made, and responsibe attitudes taken by the leading system suppliers. Licensing and cooperative agreements are becoming more common, as are improvements in technical information and construction details.

For field applied systems, the control of conditions and of the formulation and application of the finish coat may be more difficult than in the factory. Optimum tensile strength and ductility may not be reached and closer spacing of joints might well compensate for any such anomolies. Closer spacing of joints will also result in less movement at individual joints and thus place less demands on the joint closure material. Reinforcing mesh should be discontinuous at all joints, and interruption of application should be scheduled to occur at a convenient joint location.

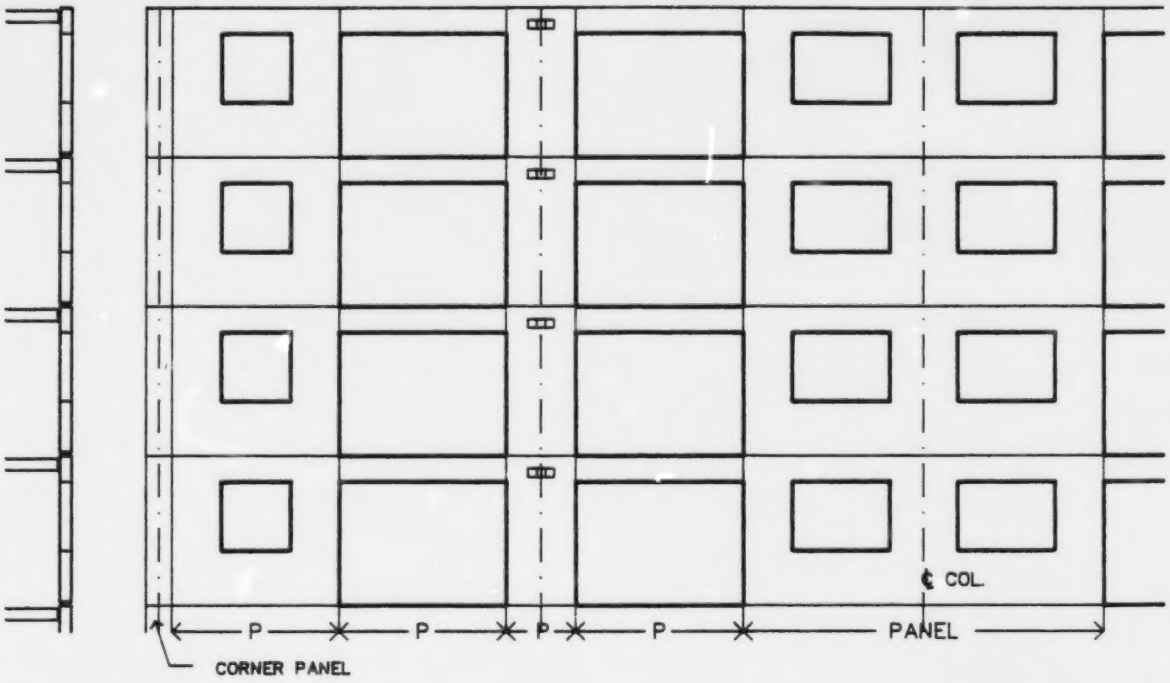
Joints should coincide with recognizable features of the building façade. Horizontal joints at window heads and sills are most easily detailed and are less prone to water penetration than vertical joints at window jambs and mullions. Although they are likely to be subjected to a localized concentration of water flow under wind-driven rain, interior corners at column expressions or other vertical lines are the most suitable locations for vertical joints.

Joints in panel systems should similarly be integrated into the architectural treatment of the façade. Horizontal joints above and below windows and vertical joints at internal corners. At external corners, separate corner panels should be considered, butt-jointed to the meeting panels of each façade. In this way, the corner is protected, and wind-driven rain run-off does not concentrate at a joint.

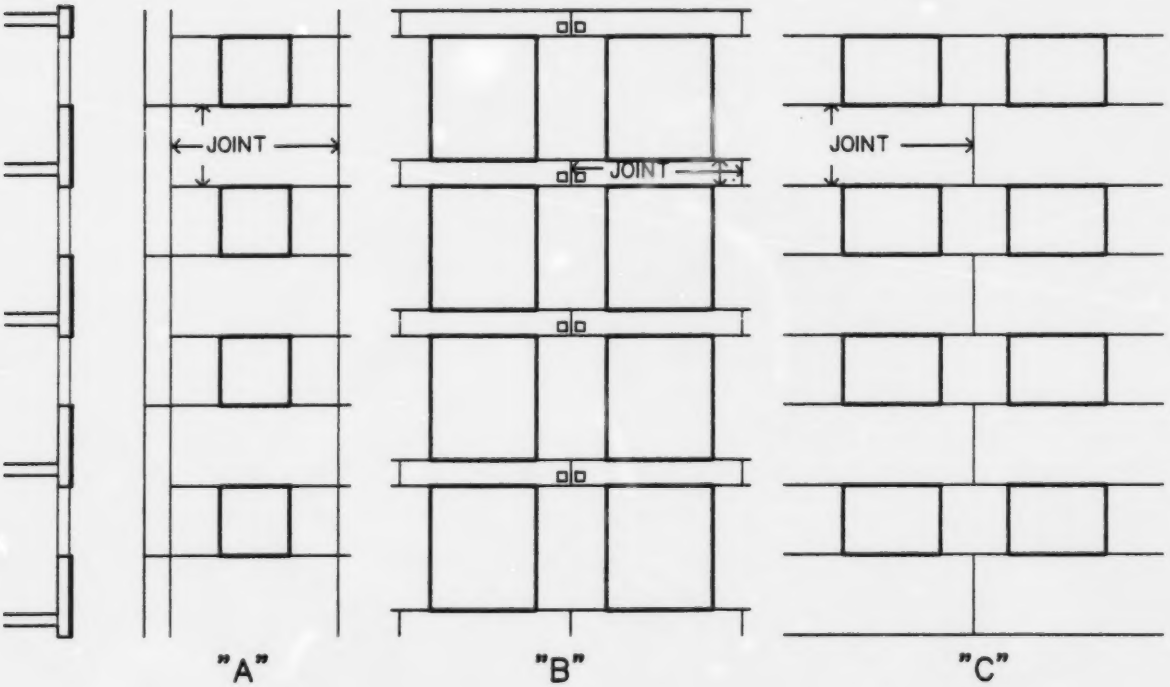
From the standpoint of overall envelope performance, the development of recommended details for the installation of window components in both field applied and panelized systems would be useful. For panelized systems, recommended details for panel joints should also be developed, recognizing the unique opportunity afforded by the EICFS system for access from inside the building. Some suggestions in this regard have been advanced in Section 2.4.

The application of panelized EICFS systems in retrofit situations should also be considered. When existing masonry cladding has deteriorated, the method of fastening field applied systems can pose problems. Panelized systems can be structurally designed to span between floor slabs, a particularly convenient as well as beneficial feature for high-rise buildings with exposed floor slab edges. With such applications, the use of compressible, mineral fibre or foamed plastic insulation that is thicker than the metal frame in which it is installed, would serve to fill the space between the panel and the exterior face of the wall and avoid unwanted air circulation.

Although the added insulation would also be of benefit for energy conservation, the resultant temperatures of the gypsum sheathing and metal fasteners should be investigated to assess the probability of condensation and corrosion. Such thermal testing would also provide pertinent information for the assessment of corrosion and condensation potential in new building construction



RECOMMENDED JOINT PLACEMENT – PANEL SYSTEM



RECOMMENDED JOINT PLACEMENT – FIELD APPLIED SYSTEM

REFERENCES

(1) Selby, K, Timusk, J., et al, The Evaluation of Retrofit Cladding Systems on OHC Buildings, June 1988.

(2) TROW INC., Comparitive Study of Two Exterior Insulation and Stucco Finish Systems, November 1987.

(3) Duffy, J. P. A., Cracking of Stucco On Insulation Board, M.A.Sc. Thesis, University of Toronto, August 1983.

(4) Shah, S. P. et al, Toughness-Durability of Glass Fiber Reinforced Concrete Systems, ACI Materials Journal / September-October 1988

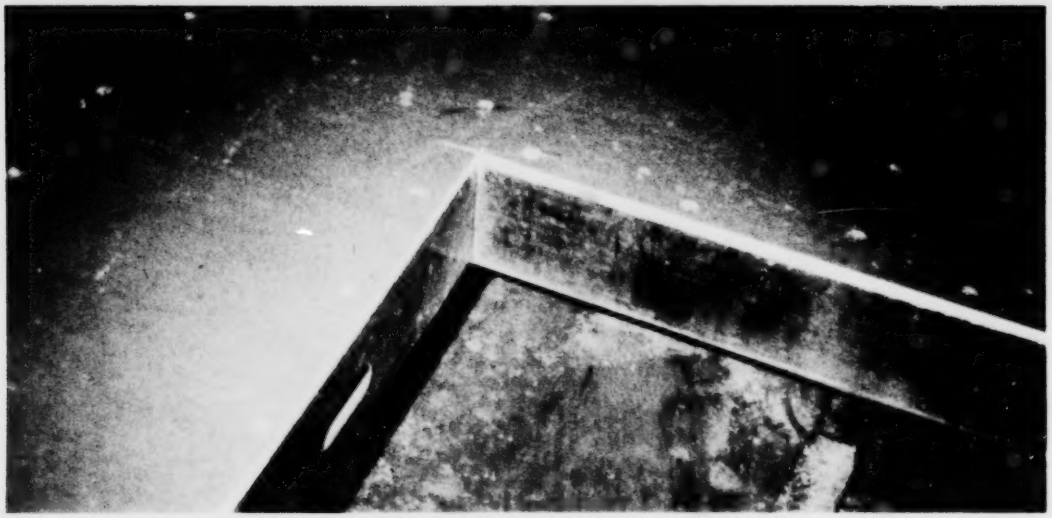
(5) Handegord, G. O. and Karpati, K. K., Joint Movement and Sealant Selection, Canadian Building Digest No. 155, DBR/NRCC, 1973.

(6) Piper, Richard, Troubles With Synthetic Stucco, New England Builder. June 1988.

(7) Handegord, G. O., Prediction of the Moisture Performance of Walls, ASHRAE Transactions V. 91, Pt. 2, 1985.

(8) Yung, D. and Oleszkiewicz, I., Fire Spread Via Exterior Walls of Buildings, Proceedings of the Fourth Conference on Building Science and Technology, p. 1-12, February, 1988 (IRC Paper No. 1532).

ILLUSTRATIONS



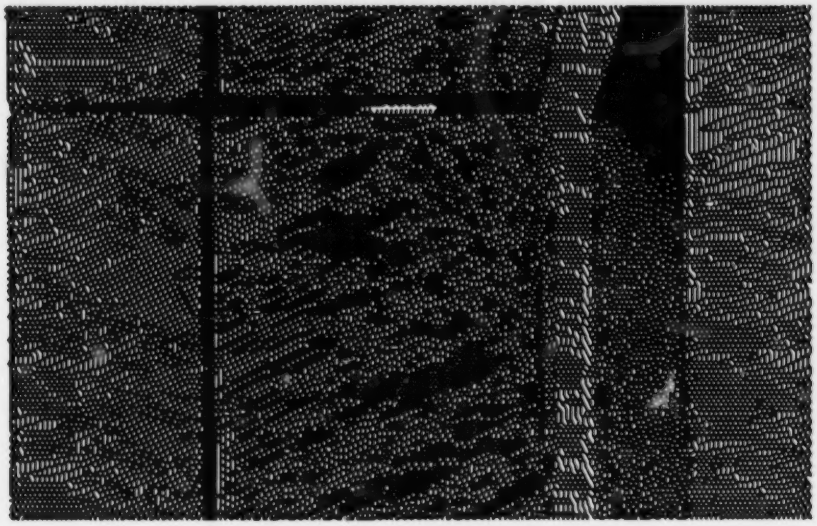
INSTALLATION OF GYPSUM SHEATHING ON METAL FRAME
NOTE - CONTINUATION OF SHEATHING AT CORNER

ROUTING OF ARCHITECTURAL PROFILE IN INSULATION BOARD OF EICFS PANEL

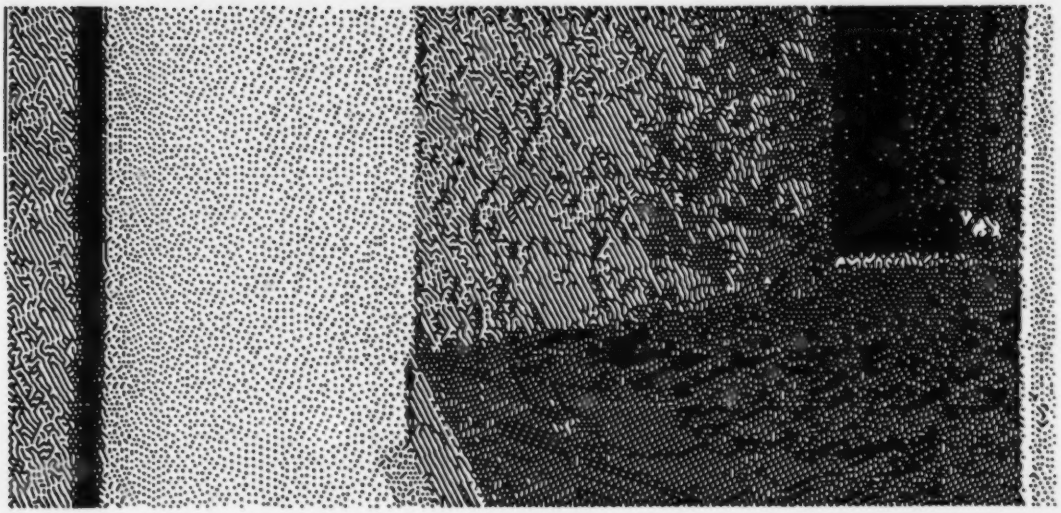
BRACKET MOUNTING PANEL TO FLOOR SLAB

EICFS PANELS INSTALLED

NOTE - DRIP AT WINDOW HEAD AND PROVISION OF SILL FLASHING



VARIATION IN WIDTHS OF PANEL JOINTS

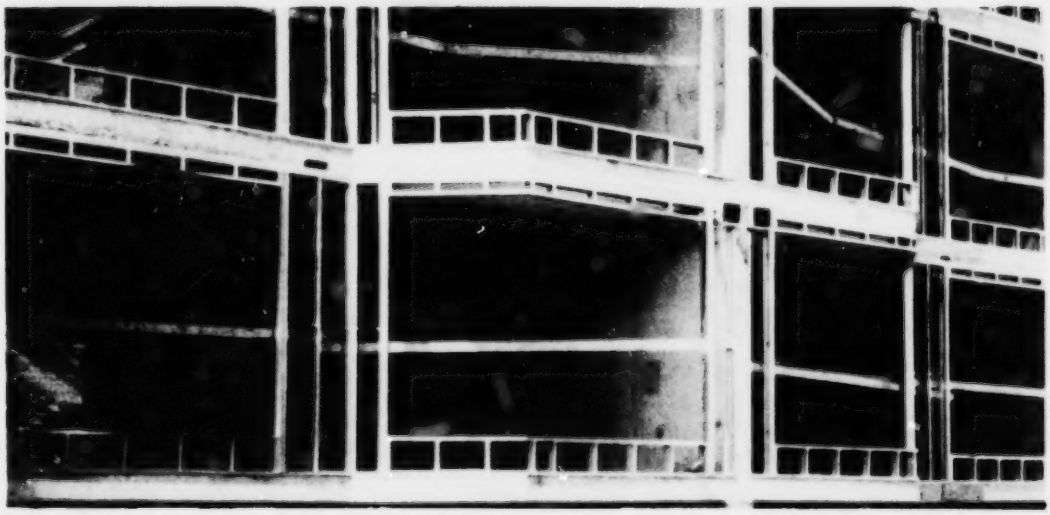


WINDOW OPENING IN PANEL

NOTE - MESH AND COATING CARRIED AROUND CORNERS

UPTURN IN FLASHING WOULD BE USEFUL

INSTALLATION OF HIGH DENSITY MINERAL WOOL FIRESTOP BETWEEN PANEL AND SLAB EDGE



STUD WALL INSTALLED FOR FIELD APPLIED EICFS

COMPLETED FIELD APPLIED EICFS ELEVATION
NOTE - CORNICE DETAILING

SECTION 2
SPECIFICATIONS & CHECKLISTS

DEFINITIONS

A. Adhesive/Base Coats: Adheres the insulation board to the substrate and may also perform as the base to embed the reinforcing fabric and receive the finish coat.

B. Applicator: The subcontractor who installs the system. This subcontractor is trained in the installation of the field-applied EICFS and certified and listed as a trained applicator by the particular EICFS manufacturer.

C. Accessories: Linear formed metal or plastic members designed to form corners, edges, control joints, and decorative effects.

D. Base Coat: The first coat applied to the surface of the insulation board.

E. Breathable: Allows water to pass in its gaseous (vapour) state; does not allow the passage of liquid water.

F. Cold Joint: The juncture of wet material with set material.

G. Curing Time: Time between coats or movement of panels.

H. EICFS System (Exterior Insulated Cementitious Finish System): System comprised of insulation board, adhesive/base coat fasteners, reinforcing fabric, finish coat, and applicable accessories that interact together to form an exterior wall.

I. Fabricator: The subcontractor who fabricates the system. This subcontractor is trained in the fabrication of the particular EICFS and certified and listed as a trained fabricator by the EICFS manufacturer.

J. Fasteners, Mechanical: A metal connector utilized to fasten the insulation board to the substrate.

K. Finish Coat: The final coat applied over the base coat.

L. Insulation Board: A component of the system that functions to reduce heat transfer through the wall and serves as the surface to receive the finish system.

M. Lapping: The overlap of the reinforcing mesh as required by type of mesh used and as recommended by EICFS manufacturer.

N. Primers: Products utilized as adhesion intermediaries between the system and the substrate, as recommended by some manufacturers.

O. Reinforcing Fabric: Balanced, open mesh fibreglass fabric treated for compatibility (alkali resistant) with other materials of the system which functions to strengthen the system.

P. Set: The chemical and physical change that occurs as the material goes from a plastic, workable state to a solid state.

Q. Substrate: The underlying component to which a material is attached.

R. Wet Material: The material used for the base and finish coat that is in a plastic workable state.

S. Wrapping: Enclosing the insulation board by continuing mesh, base coat and finish over all exposed edges of the insulation board.

Exterior Insulated Cementitious Finish System (EICFS)

PREFABRICATED PANEL SPECIFICATION/CHECKLIST

PART 1 - GENERAL

1.1 All Conditions of the Contract apply to this section.

1.2 Related Work specified elsewhere:

Section 04200	-	Concrete Masonry
Section 08520	-	Windows
Section 05400	-	Metal Studs

1.3 **Scope of Work**

1.3.1 **Fabrication and Erection of Wall Systems**

Supply all labour, materials and equipment necessary to manufacture and install the prefabricated wall system panels.

Prefabricated wall system is further referred to as a "System" and consists of the following:

- Metal Stud Framing
- Exterior Sheathing
- Insulation Board
- Polymer base of modified reinforced finish
- Accessories

The Scope of Work will include but will not be restricted to the following:

- Submission of all required test results to municipal building official;
- Design, engineering and construction of the system and components;
- Submission of shop drawings for approval by Consultant;
- Manufacturing of the system's Panels as indicated by the manufacturer's specifications and drawings and as shown in contract drawings;
- Inspection and preparation of a structural frame of the building to receive panels;
- Provision of anchorage, connections, sealants and other related secondary components;
- Erection of the Panels;
- Provision of fire stopping where necessary;
- Sealing of joints between panels and between panels and windows and other parts of the buildings, installation of flashings and miscellaneous metal as required and indicated on the drawings;

1.3.2 Testing

Supply and install three panels, each approximately 1 m x 3.5 m in size, in a testing laboratory for visual approval, rain penetration and wind load tests. Provision for the installation of a window assembly shall be made in one panel if indicated on drawings.

The scope of work will include, but will not necessarily be restricted to, the following:

- installation of representative prefabricated panels into test chamber frame;
- sealing of all panel to panel, panel to window, and panel to test frame joints;
- installation and welding of two horizontal steel supports to test frame to simulate actual anchorage details. Note: That testing company will supply horizontal supports, test chamber and frame;
- removal of test panels upon completion of laboratory tests.

1.4 Quality Assurance

1.4.1 Panel Fabricator

The panel fabricator shall have adequate plant, equipment and skilled tradesmen to fabricate the panels expeditiously, shall be known to have been responsible for satisfactory fabrication similar to that specified and shall have been approved by the manufacturer for a minimum of 2 years.

The fabrication of the steel framing shall be conducted in a plant certified to CSA 47.1-1983 standards and welders shall be certified to CSA 178.2-1983 standards.

The successful bidder must furnish evidence of certification, manufacturer's approval and related work history within 5 working days from notification of acceptance of bid.

1.4.2 Panel Erector

The Panel Erector shall be the Panel Fabricator, or approved by and under the direct supervision of the Panel Fabricator, who will assume responsibility for the completed work.

1.4.3 Allowable Tolerances

All Prefabricated Wall Panels shall meet the required dimensions, as indicated on the shop drawings plus or minus 5 mm (3/16").

1.4.4 Plant Inspections

The Panel Fabricator shall co-operate with the independent inspection company retained by the Client, certified to CSAW 159-M84 standards.

The Panel Fabricator shall also require the manufacturer to provide periodic inspections as required.

1.4.5 Erection Inspections

The Panel Erector shall co-operate with the independent inspection company retained by the Client, and certified to CSAW 159-M84 standards to inspect the anchorage connection during the erection process.

1.4.6 Design and Performance Requirements

Design, fabricate and install wall system panels and components to the following criteria:

- Meet the requirements of authorities having jurisdiction and governing codes;
- Engineer system to withstand all applicable loads including positive and negative wind loads, erection loads, live loads, stress due to creep and deflection, seismic loads and any other loads and forces affecting any part of the system;
- The maximum deflection of the panel system under full positive and negative design wind loads shall not exceed 1/240th of the span.
- Provide design calculations for the various components of the system to assure that all applicable performance requirements have been met. Calculations must be prepared and sealed by a Professional Engineer licensed to practice in Ontario and having knowledge in the application of the EICFS system.
- Include fire stopping to separate fire compartments as required by the code(s).
- Analyze bond strength, fasteners and connection strength, and engineer to meet appropriate factors of safety.
- No water shall be allowed to penetrate through the system to the exterior surface of the substrate when tested in accordance with ASTM E331-70 Water Penetration of Exterior Windows, Curtain Walls and Doors at uniform static air pressure difference of 300 Pa.
- All panel to panel, panel to window and panel to adjacent component joints shall be designed to include an inner and outer seal with a pressure equalized drained cavity between seals.

- The prefabricated wall system shall be designed to have a minimum RSI thermal resistance of 2.11. Fibreglass batt insulation where indicated (placed between steel stud framing member) shall be included in the determination of total RSI value.

1.5 Submissions

1.5.1 Shop Drawings

.1 Submit shop drawings showing all components of the Prefabricated Wall System in as large a scale as practical, showing methods of joining, bonding, fastening, sealing, anchorage, as well as type of material, thicknesses, finishes, and other pertinent data.

All shop drawings shall bear the approval stamp of the Manufacturer and the Seal of a Professional Engineer licensed to practice in Ontario who is responsible for the design.

.2 Show details of the work of this section. Show details of adjoining work of other sections. Provide specific details as follows:

a) window jamb, head and sill;
b) cladding termination near grade;
c) terminations at roof(s);
d) corners, inside and outside;
e) termination at sides; and
f) other details as required or as requested by the Consultant.

.3 Shop drawings must conform to the Contract Documents unless directed otherwise in writing by the Consultant.

1.5.2 Samples

.1 Submit to the Consultant a 300 mm x 300 mm sample of all materials, with their respective finishes. Samples shall represent the physical and chemical properties of the materials to be installed.

1.5.3 Reports, Calculations, Testing and Certificates

.1 Upon submission of the Tender, the Contractor shall submit all technical data and all testing data including full scale fire test results from the Manufacturer and have the Manufacturer confirm the compatibility of all materials.

.2 Engineering calculations verifying the structural performance of the Exterior Insulation and Finish System shall be submitted to the Consultant.

.3 Submit a copy of the current Certificate of Approval (by the Manufacturer) to the Consultant prior to commencing the work.

1.5.4 Erection Procedure

.1 Before fabrication, submit outline of panel erection procedure, method of swinging, proposed sequence, and timing of work, etc.

1.5.5 Mock-Up

.1 As per Section 1.3.2 Testing.

1.6 Warranty

1.6.1 The warranty period stipulated in the General Conditions of the Contract shall be made in writing and extended as follows:

- The Contractor and Manufacturer shall jointly warrant that the Work shall not leak, shall be free of defects of materials, workmanship and performance, including excessive heat transmission, formation of icicles, excessive fading of finish, excessive change in colour or other deterioration such as cracking or grazing for 5 (five) years from date of Total Performance.

- The Contractor and Manufacturer shall accept responsibility for all deficiencies in materials, workmanship and design, and take whatever measures are necessary for satisfactory remedy. The Contractor and Manufacturer shall agree to make good any defects and replace defective units. Replacement to include removal of defective units and installation of replacement units, including removal and replacement of adjacent materials as required to allow for replacement of defective unit.

1.7 Product Delivery, Storage and Handling

1.7.1 Materials

A. Deliver all materials in manufacturers' standard containers or packages.

B. Store material in a manner to protect from weather and physical damage. Materials should be stored at a temperature not less than 5°C and out of the sun. Sheet material should be stored flat and be uniformly supported. Protect unfinished insulation from direct sunlight.

C. Material suspected of having been subjected to freezing should not be used unless the Manufacturer verifies in writing that the material has not been damaged.

1.7.2 Panels

.1 Store panels on site where directed.

.2 Store off ground, under cover, protected from weather and construction activities.

.3 Deliver panels to the site in a manner insuring installation continuity.

.4 Store and handle panels to insure against racking, buckling, creeping, distortion, staining or other physical damage.

1.8 Job Conditions

1.8.1 Fabrication of panels should be at temperatures above 5°C.

1.8.2 Install panels in strict accordance with all weather and safety conditions as required by all municipal, provincial and federal regulatory agencies having jurisdiction.

1.8.3 Protection

.1 Protect surrounding areas and surfaces to preclude damage during installation of the prefabricated wall system panels.

.2 Protect finished work when stopping for the day or when completing an area in order that water will not penetrate behind the prefabricated wall system panels.

1.8.4 Coordination

.1 Ensure that the work of this section is closely coordinated with the work of related sections.

.2 The cap flashing shall be installed as soon as possible after the installation of the prefabricated wall system panels.

.3 Caulk joints as soon as possible after the installation of the prefabricated panels.

PART 2 - PRODUCTS

2.1 Material

2.1.1 The exterior insulated cementitious finish system components shall be as specified by the Manufacturer and form current stocks.

2.1.2 Structural Framing

.1 Meet the requirements of ASTM A570-66T Grade D with minimum yield point of 50,000 psi.

.2 Provide framing in sections and thicknesses suitable to meet the design loads.

.3 All structural framing and accessories shall be galvanized. Provide zinc primer over all weldments.

.4 All shop and field welding shall conform to American Welding Society (AWS) standards.

a. Welding rod shall be an appropriate AWS E60XX Type.

b. All welding shall be subject to the Manufacturer's approval.

2.1.3 Sealant

Two part polyethylene sealant to meet the requirements of CAN2-19.24-M80.

Sealant Primer:
Non-staining primer to suit applicable joint conditions and as recommended by Sealant Manufacturer.

Backing Rod:
Extruded, foamed, closed cell, round, polyethylene, urethane, neoprene, or vinyl rod, 50 percent wider than joint width, with Shore "A" hardness of 20 and 830-900 kPa tensile strength, manufactured especially for the purpose, and compatible with and as recommended by the Sealant Manufacturer.

PART 3 - EXECUTION

3.1 Inspection

.1 Examine areas to receive prefabricated wall system panels for deviations from contract documents which will adversely affect installation.

.2 Do not start work until unsatisfactory conditions are corrected.

3.2 Preparation

.1 Before fabrication of panels, fabricator is to take field measurements.

3.3 Workmanship

.1 Perform work in accordance with manufacturers' printed instructions.

.2 Where manufacturers' printed instructions are not available, or a situation is ambiguous or unique, consult the manufacturer's Technical Representative and the Consultant (at the project site) to review the situation and make clarifications. Instructions will be confirmed in writing by the Consultant and/or Manufacturer.

3.4 Coordination

.1 Coordinate all work carried out under this Contract with other trades.

.2 Examine all areas before commencing work to ensure that work done by other trades is complete and ready to receive the panels. Report in writing to the Owner and Consultant any conditions which will adversely affect cladding performance. Commencement of work shall imply acceptance of existing conditions.

3.5 Fabrication of Panels

.1 Manufacture panels in accordance with approved shop drawings and manufacturer's printed instructions.

3.6 Erection of Panels

.1 Erect panels in accordance with schedule of panel erection procedures approved by Consultant.

.2 Installation shall be by Fabricator or under direct supervision of Fabricator.

.3 Set each unit plumb, level and true in line with uniform joint width and tolerance as specified on the shop drawings.

.4 Field weld or bolt connections to the structure in accordance with the shop drawings.

.5 Installer must verify actual field dimensions prior to installation and provide all materials and labour necessary to insure anchorage of the prefabricated panels to the structure.

.6 Allow for moulding and/or panel movement at panel connections.

3.7 Sealing of Joints between Panels and between Panels and Windows and other parts of the Building

.1 Execute work as per Section 07900 - Sealants and in accordance with relevant drawings and details.

3.8 Installation of Flashings and Other Miscellaneous Metal

.1 Execute work as per Section 07620 - Metal Flashing and Trim and in accordance with relevant drawings and details.

3.9 Final Cleaning

.1 Remove all material left over by Panel Erector at the job site.

.2 Clean adjacent materials and surfaces and the work area of foreign materials resulting from their work.

2.3.2 CHECK LIST - PANEL SYSTEM

Project: **Project Name:**

Date:

Report No.:

		YES	NO
1)	**MATERIAL STORAGE**		
	All materials and products stored in a warm, dry environment (5°C).		
2)	**FRAMES**		
	Size of frame members as specified.		
	Panels are square.		
	All weldments are as specified.		
	All welds have been primed with zinc rich primer.		
	Allowable tolerances of panels are within required dimensions as indicated on shop drawings.		
3)	**SUBSTRATE**		
	All extraneous holes through gypsum sheathing are patched.		
	Sheathing secured with appropriate fasteners or adhesive(s) at intervals recommended by Manufacturer.		
4)	**INSULATION**		
	Insulation boards butt tightly together.		
	Surface of insulation is level between insulation boards.		
	Joints between insulation boards do not occur at corners of openings.		
	Washers do not penetrate insulation by more than 1/4" (6.5 mm).		
	Insulation joints are off-set from substrate joints.		
	Minimum of 3/4 inch (19 mm) of insulation board left after any aesthetic grooves are cut.		

		YES	NO
5)	**MESH**		
	Mesh covers all surfaces of insulation including edges.		
	Mesh is double-wrapped at all edges and overlapped with outer mesh covering substrate edges.		
	Joints in mesh are overlapped between 3" to 4" (75 - 100 mm).		
	Mesh is continuous at corners of opening.		
	Mesh is relatively flat against the insulation without ripples.		
	Mesh is entirely embedded in base coat.		
6)	**FASTENERS**		
	Fasteners are as specified by Manufacturer.		
	Fasteners are at spacings specified by Manufacturer.		
7)	**APPLICATION**		
	Insulation is free of dust and dirt.		
	Base coat is applied to the edges of the panel and covers the substrate.		
	All insulation and mesh is covered with the base coat.		
	Areas to receive sealant are left smooth, without stone aggregate.		
8)	**CURING AND MOVEMENT**		
	Panels are allowed to cure for a minimum of 48 hours before being moved.		
	Area around curing panels is well ventilated with warm dry air.		

SUMMARY

Inspection conducted by:

Date:

If any points have been answered "NO", elaborate below:

Panel Identification Number:

Discussed with Fabricator:

Contact:

Discussed with Manufacturer/Consultant:

Contact:

Deficiencies to be resolved by:

Signature Date

Exterior Insulated Cementitious Finish System (EICFS)

FIELD APPLICATION SPECIFICATION/CHECKLIST

PART 1 - GENERAL

1.1 All Conditions of the Contract apply to this section.

1.2 Related Work specified elsewhere:

Section 04200	-	Masonry
Section 05400	-	Metal Studs
Section 06100	-	Rough Carpentry
Section 08520	-	Windows

1.3 Scope of Work

1.3.1 Installation of Field-Applied Wall System

Supply all labour, materials and equipment necessary for the installation of the field-applied wall system.

The field applied wall system is further referred to as a "System" and consists of the following:

- Substrate;
- Insulation Board
- Polymer base of modified reinforced finish
- Accessories.

The Scope of Work will include, but will not necessarily be restricted to, the following:

- Submission of all required test results to a Municipal Building Official;
- Design, engineering and construction of the system and components;
- Submission of shop drawings for approval by the Consultant;
- Installation of the system as indicated in the manufacturers' specifications and drawings and as shown in contract documents;
- Cleaning and preparation of the surface to receive the field-applied system;
- Provision of anchorage, connections, sealants and other related secondary components;
- Installation of joints, flashings and other miscellaneous metal as needed and as indicated on the drawings;
- Sealing of joints and between system and windows and other parts of the buildings;
- Final cleaning.

1.4 Quality Assurance

1.4.1 Systems Applicator

The Applicator shall have adequate plant, equipment and skilled tradesmen to install the system expeditiously, shall be known to have been responsible for satisfactory installation similar to that specified and shall have been approved by the Manufacturer for a minimum of 2 years.

1.4.2 Site Inspections

The Applicator shall engage the services of an independent inspection company, acceptable to the Client, certified to CSAW 159-M84 Standards.

The Applicator shall also require the Manufacturer to provide periodic inspections as required.

1.4.3 Design and Performance Requirements

Design and install the field-applied system to the following criteria:

- Meet the requirements of authorities having jurisdiction and governing codes;
- Engineer system to withstand all applicable loads, including live, dead, positive, or negative wind loads, stress due to creep and deflection, seismic loads and forces affecting the system.
- Provide design calculations for the various components of the system to verify that all applicable performance requirements have been met. Calculations must be prepared and sealed by a Professional Engineer licensed to practice in Ontario and having knowledge and experience in the application of the EICFS system.
- Install continuous expansion or control joints at the following locations:
    - where expansion joints occur in the substrate systems;
    - where the system abuts other materials;
    - where the substrate changes;
    - where significant structural movement occurs.
- Supply and install fire stopping to separate fire compartments as required by the Code(s).
- Analyze bond strength, fasteners and connection strength, and engineer to meet appropriate factors of safety.
- The maximum deflection of the substrate system under full positive and negative design wind loads shall not exceed 1/240th of the span.
- No water shall be allowed to penetrate through the system to the exterior surface of the substrate when tested in accordance with ASTM E331-70 Water Penetration of Exterior Windows, curtain walls and doors at uniform static air pressure difference of 300 Pa.
- The wall system shall be designed to have a minimum RSI thermal resistance of 2.11. Fibreglass batt insulation where indicated (placed between steel stud framing member) shall be included in the determination of total RSI value.

1.5 Submissions

1.5.1 Shop Drawings

.1 Submit shop drawings showing all components of the Wall System assemblies in as large a scale as practical, showing methods of joining, bonding, fastening, sealing, anchorage, as well as type of material, thicknesses, finishes and other pertinent data.

All installation shop drawings shall bear the approval stamp of the Manufacturer or the Seal of a Professional Engineer licensed to practice in Ontario who is responsible for the design.

.2 Show details of work of this section. Show details of adjoining work of other sections. Provide specific details as follows:

a) window jamb, head, and sill;
b) cladding termination near grade;
c) terminations at roof(s);
d) corners, inside and outside;
e) termination at sides; and
f) other details as required and/or as requested by the Consultant.

.3 Shop drawings must conform to the Contract Documents unless directed otherwise in writing by the Consultant.

1.5.2 Samples

.1 Submit to the Consultant a 300 mm x 300 mm sample of all materials, with their respective finishes. Samples shall represent the physical and chemical properties of the materials to be installed.

1.5.3 Reports, Calculations, Testing and Certificates

.1 Upon submission of the Tender, the Contractor shall submit all technical data and all testing data including full scale fire test results from the Manufacturer and have the Manufacturer confirm the compatibility of all materials.

.2 Submit engineering calculations verifying the structural performance of the Exterior Insulation and Finish System to the Consultant.

.3 Submit a copy of the current Certificate of Approval (by the Manufacturer) to Consultant prior to commencing the work.

1.6 Warranty

1.6.1 The warranty period stipulated in the General Conditions of the Contract shall be extended as follows:

- The Contractor and Manufacturer shall jointly warranty that the work shall not leak, shall be free of defects of material, workmanship and performance, including excessive heat transmission, formation of

icicles, excessive fading of finish, excessive change in colour, or other deterioration such as cracking or grazing for 5 (five) years from date of Total Performance.

- The Contractor and Manufacturer shall accept responsibility for all such deficiencies in material, workmanship and design, and take whatever measures are necessary for satisfactory remedy. The Contractor and Manufacturer shall agree to make good any defects and replace defective units. Replacement to include removal of defective units and installation of replacement units, including removal and replacement of adjacent materials as required to allow for replacement of defective units.

.2 The Contractor and Manufacturer shall further agree that, at any time within these warranty periods and without cost to the Owner, they shall:

- Make weathertight joints which are not weathertight;
- Replace finish if it develops excessive fading, change in colour, or other deficiencies, such as cracking, peeling, etc.
- Replace and make good any other work of this section which is or becomes defective.

1.7 Product Delivery, Storage and Handling

1.7.1 Store materials on site where directed.

.1 Store off ground, under cover, protected from weather and construction activities with the ambient temperature above 0°C or greater. Protect unfinished insulation from direct sunlight.

.2 Material suspected of having been subjected to freezing should not be used unless the Manufacturer verifies in writing that the material has not been damaged.

1.8 Job Conditions

.1 The ambient air temperatures shall be 5°C or greater at the time of installation of the materials and shall remain so far at least 24 hours thereafter.

.2 The materials shall not be applied to frozen substrates.

.3 The materials shall not be applied during periods of inclement weather. If inclement weather is expected during 24 hours after installation, the work must be protected from damage.

1.8.1 Protection

.1 Protect surrounding areas and surfaces to preclude damage during installation of the Wall System.

.2 Protect finished work when stopping for the day or when completing an area in order that water will not penetrate behind the Wall System.

1.8.2 Coordination

.1 Ensure that the work of this section is closely coordinated with the work of related sections.

.2 The cap flashing shall be installed as soon as possible after the installation of the Wall System.

.3 Caulk joints as soon as possible after the installation of the Wall System.

PART 2 - PRODUCTS

2.1 Material

2.1.1 The wall system and components shall be as specified by the Manufacturer and supplied from current stocks. No substitutes of, or additions to other materials shall be done without prior written permission of the Manufacturer and Consultant.

2.1.2 Structural Framing

.1 Meet the requirements of ASTM A570-66T Grade D with minimum yield point of 50,000 psi.

.2 Provide framing in sections and thicknesses suitable to meet the design loads.

.3 All structural framing and accessories shall be galvanized. Provide zinc primer over all weldments.

.4 All field welding shall conform to American Welding society (AWS) Standards.

a. Welding rod shall be an appropriate AWS E60XX Type.

b. All welding shall be subject to the Manufacturer's approval.

2.1.3 Sealant

Two part polyethylene sealant to meet the requirements of CAN2-19.24-M80.

Sealant Primer:
Non-staining primer to suit applicable joint conditions and as recommended by Sealant Manufacturer.

Backing Rod:
Extruded, foamed, closed cell, round, polyethylene, urethane, neoprene, or vinyl rod, 50 percent wider than joint width, with Shore "A" hardness of 20

and 830-900 kPa tensile strength, manufactured especially for the purpose, and compatible with and as recommended by the Sealant Manufacturer.

PART 3 - EXECUTION

3.1 Inspection

.1 Examine areas to receive Wall System for deviations from Contract Documents which will adversely affect installation.

.2 Do not start work until unsatisfactory conditions are corrected.

3.2 Preparation

.1 Before installation, applicator is to take field measurements.

3.3 Workmanship

.1 Perform work in accordance with Manufacturers' printed instructions.

.2 Where manufacturers' printed instructions are note available, or a situation is ambiguous or unique, consult the Manufacturer's Technical Representative and the Consultant (at the project site) to review the situation and make clarifications. Instructions will be confirmed in writing by the Consultant and/or Manufacturer.

3.4 Coordination

.1 Coordinate all work carried out under this Contract with other trades.

.2 Examine all areas before commencing work to ensure that work done by other trades is complete and ready to receive the wall system. Report in writing to the Owner and Consultant any conditions which will adversely effect cladding performance. Commencement of work shall imply acceptance of existing conditions.

3.5 Job Conditions

.1 Substrate

.1 Prior to installation of the Wall System, the Substrate will be examined as follows:

- The Substrate shall be type approved by the Manufacturer;
- The Substrate surface shall be free of foreign materials such as oil, dust, direct form-release agents, paint, wax, glazing, water, moisture, frost, etc.
- The Substrate shall be examined for compliance with Contract Documents

- The Substrate shall be examined for soundness, such as tightness of connections, crumbling, spalling and delamination or loose joints, voids and projections, etc.

- The Substrate shall be examined for dimensional correctness.

.2 Advise Consultant of all discrepancies.

Do not proceed with work until unsatisfactory conditions are corrected to Consultant's satisfaction.

.2 Climatic Conditions

.1 Temperatures during application shall not be less than the minimum recommended by the Material Manufacturer. Work shall not be carried out during inclement weather conditions.

3.6 Sealing of Joints between Wall System and Windows and Other Parts of the Building

.1 Execute work as per Section 07900 - Sealants, and in accordance with relevant specifications and details.

3.7 Installation of Flashings and Miscellaneous Metal

.1 Execute work as per Section 07620 - Metal Flashing and Trim and in accordance with relevant drawings and details.

3.8 Final Cleaning

.1 Remove materials left over by applicator at the job site.

.2 Clean adjacent materials and surfaces and the work area of foreign materials resulting from their work.

2.3.1 CHECK LIST - FIELD-APPLIED SYSTEM

		YES	NO
1)	**APPLICATION CONDITION**		
	Storage of Materials		
	• Ambient temperature is above 5°C during application.		
	• Work maintained above 5°C a minimum of 24 hours after completion.		
	Substrate		
	• Approved substrates:		
	Precast Concrete _____		
	Poured in-place concrete _____		
	Masonry _____		
	Concrete Block _____		
	Other _____		
	• Substrate Condition:		
	Clean _____		
	Dry _____		
	Smooth _____		
	Spalled _____		
	Cracked _____		
	Coated (paint, sealant, etc.) _____		
	Other _____		
2)	**INSULATION**		
	• Minimum board thickness is 3/4 inch (19 mm)		
	• Insulation board joints staggered and interlocked at corners.		
	• Gaps in insulation board filled with slivers of insulation.		
	• Surface of insulation is level between insulation boards.		

		YES	NO
3)	**REINFORCING MESH**		
	• Double reinforcing installed at all openings and terminations.		
	• Corners of all openings such as windows, doors and air conditioners are diagonally reinforced with mesh.		
	• Reinforcing mesh continuous at corners and overlapped not less than 2 1/2 inches (64 mm) at mesh edges.		
	• Reinforcing mesh fully embedded in the base coat with no mesh pattern visible.		
4)	**FINISH APPLICATION**		
	• The reinforced base coat cured a minimum of 24 hours and dry prior to finish application.		
	• Finish installed continuously to a natural break such as corners, expansion or control joints. (Maintaining a wet edge).		
5)	**JOINTS**		
	• Joints installed as per manufacturer's recommendations.		

SUMMARY

Inspection conducted by:

Date:

If any points have been answered "NO", elaborate below:

Panel Identification Number:

Discussed with Fabricator:

Contact:

Discussed with Manufacturer/Consultant:

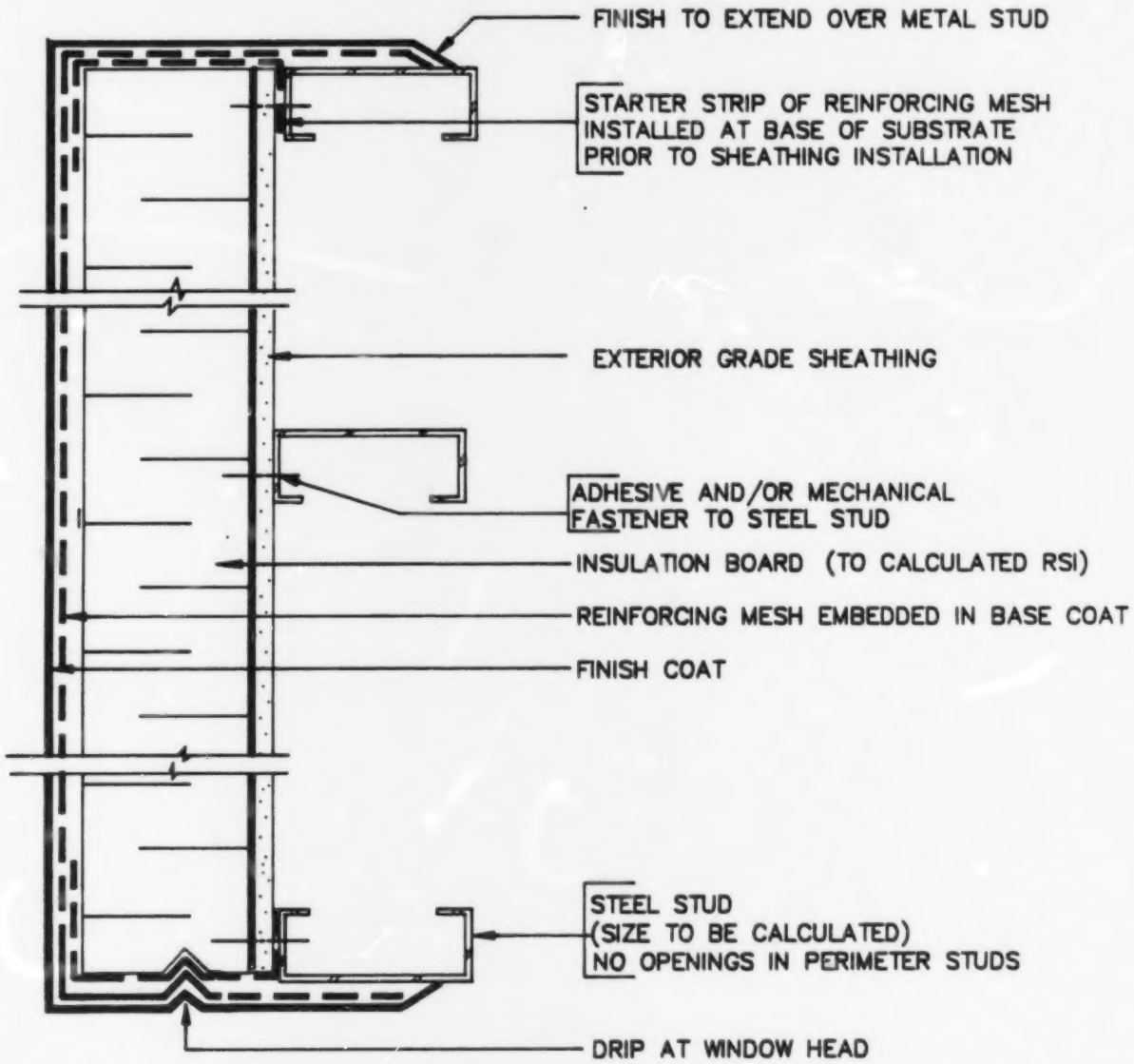
Contact:

Deficiencies to be resolved by:

Signature

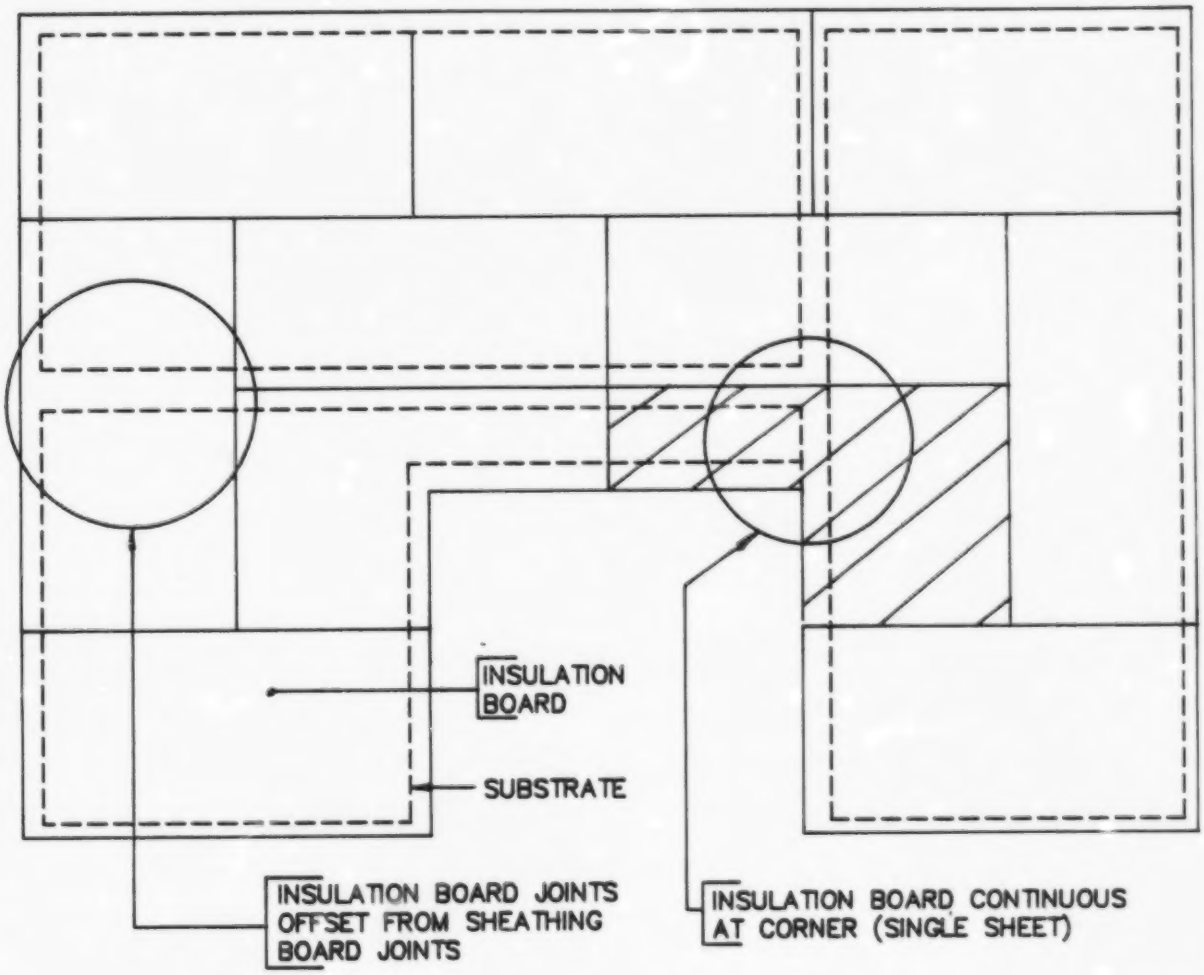
Date

SUGGESTED DETAILS


FINISH TO EXTEND OVER METAL STUD
STARTER STRIP OF REINFORCING MESH INSTALLED AT BASE OF SUBSTRATE PRIOR TO SHEATHING INSTALLATION
EXTERIOR GRADE SHEATHING
ADHESIVE AND/OR MECHANICAL FASTENER TO STEEL STUD
INSULATION BOARD (TO CALCULATED RSI)
REINFORCING MESH EMBEDDED IN BASE COAT
FINISH COAT
STEEL STUD (SIZE TO BE CALCULATED) NO OPENINGS IN PERIMETER STUDS
DRIP AT WINDOW HEAD

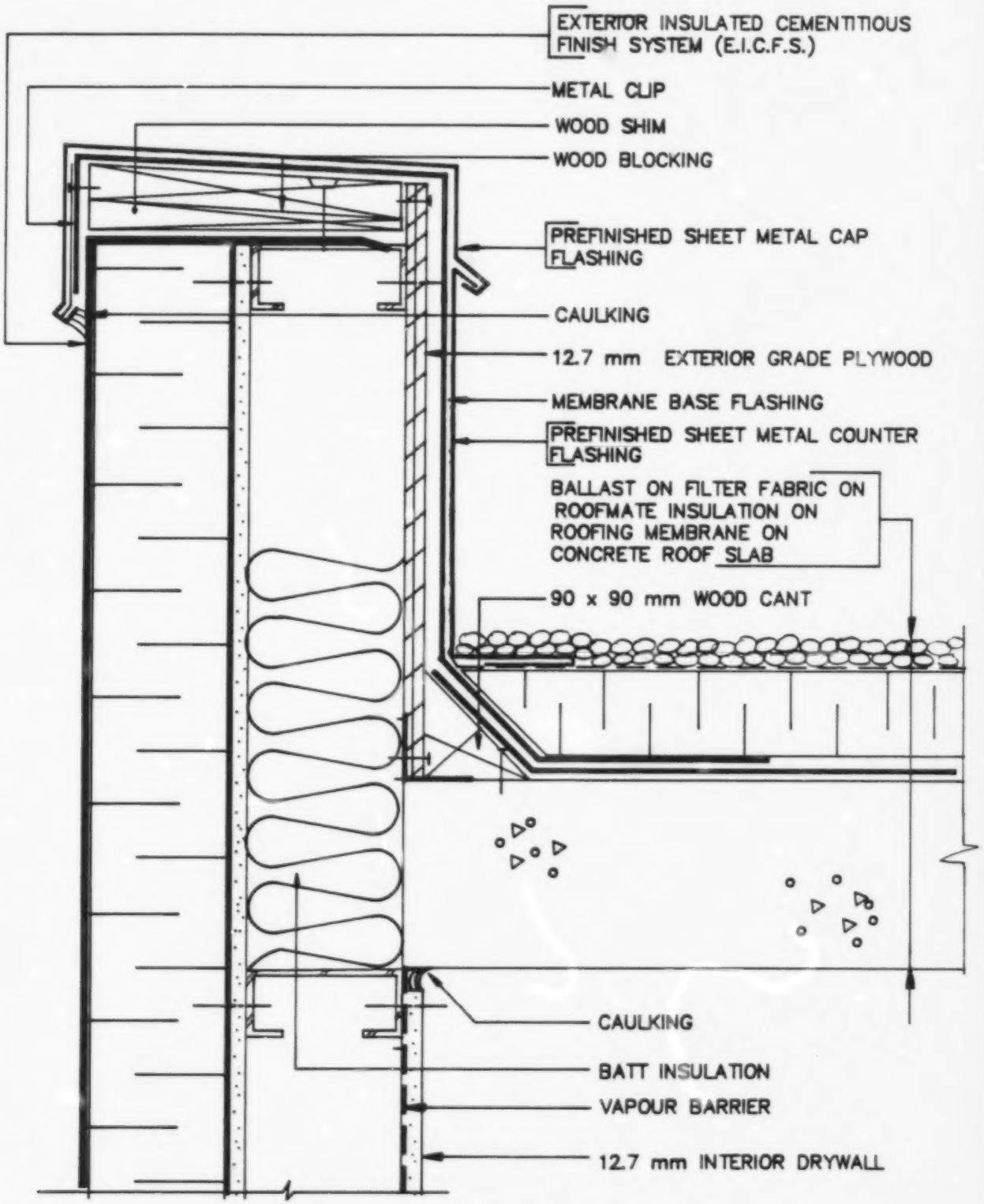
DETAIL NO.1

TYPICAL E.I.C.F.S. PANEL


INSULATION BOARD
SUBSTRATE
INSULATION BOARD JOINTS OFFSET FROM SHEATHING BOARD JOINTS
INSULATION BOARD CONTINUOUS AT CORNER (SINGLE SHEET)

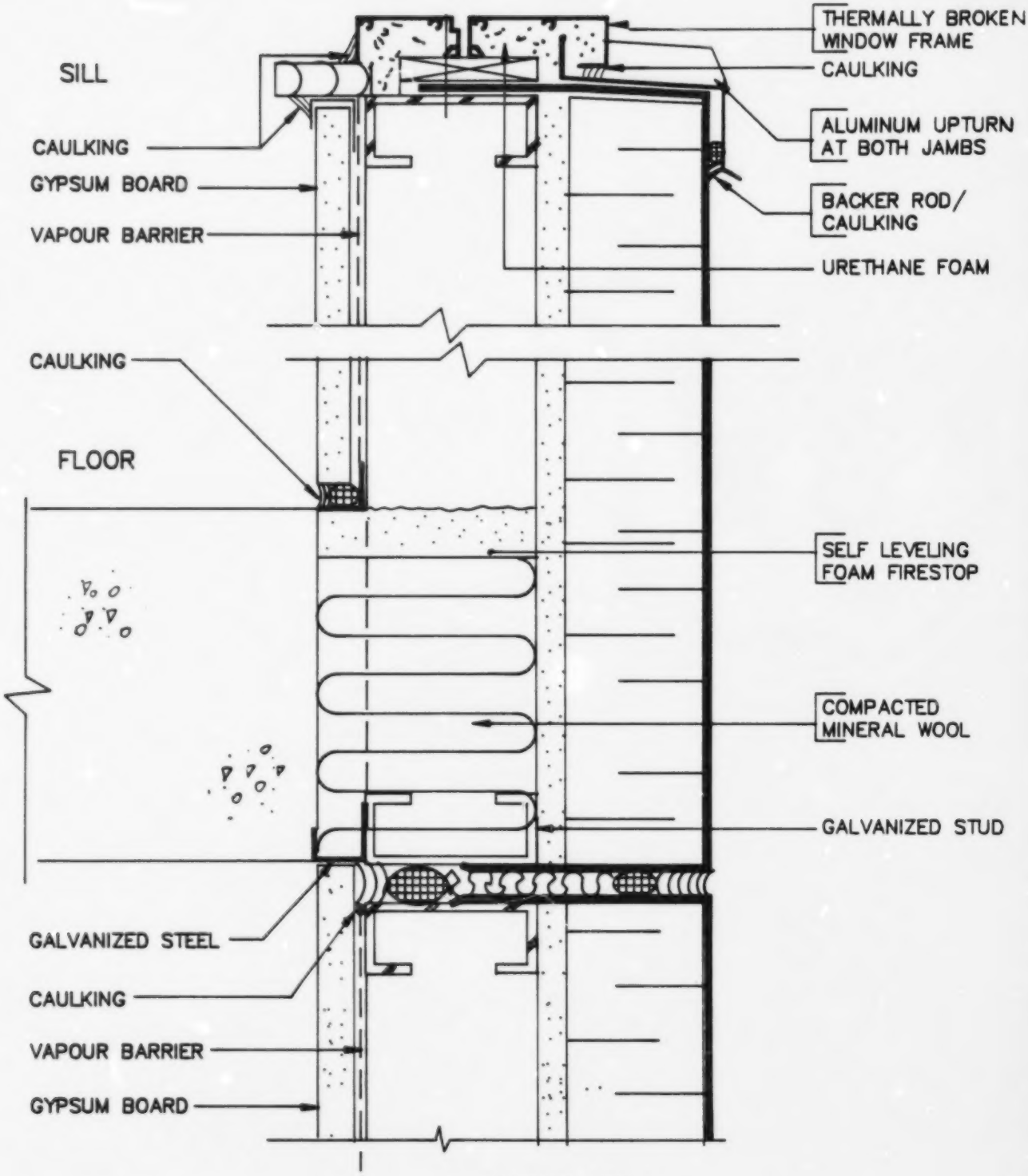
DETAIL NO.2

OFFSET OF INSULATION JOINTS


EXTERIOR INSULATED CEMENTITIOUS FINISH SYSTEM (E.I.C.F.S.)
METAL CLIP
WOOD SHIM
WOOD BLOCKING
PREFINISHED SHEET METAL CAP FLASHING
CAULKING
12.7 mm EXTERIOR GRADE PLYWOOD
MEMBRANE BASE FLASHING
PREFINISHED SHEET METAL COUNTER FLASHING
BALLAST ON FILTER FABRIC ON ROOFMATE INSULATION ON ROOFING MEMBRANE ON CONCRETE ROOF SLAB
90 x 90 mm WOOD CANT
CAULKING
BATT INSULATION
VAPOUR BARRIER
12.7 mm INTERIOR DRYWALL

DETAIL NO.3

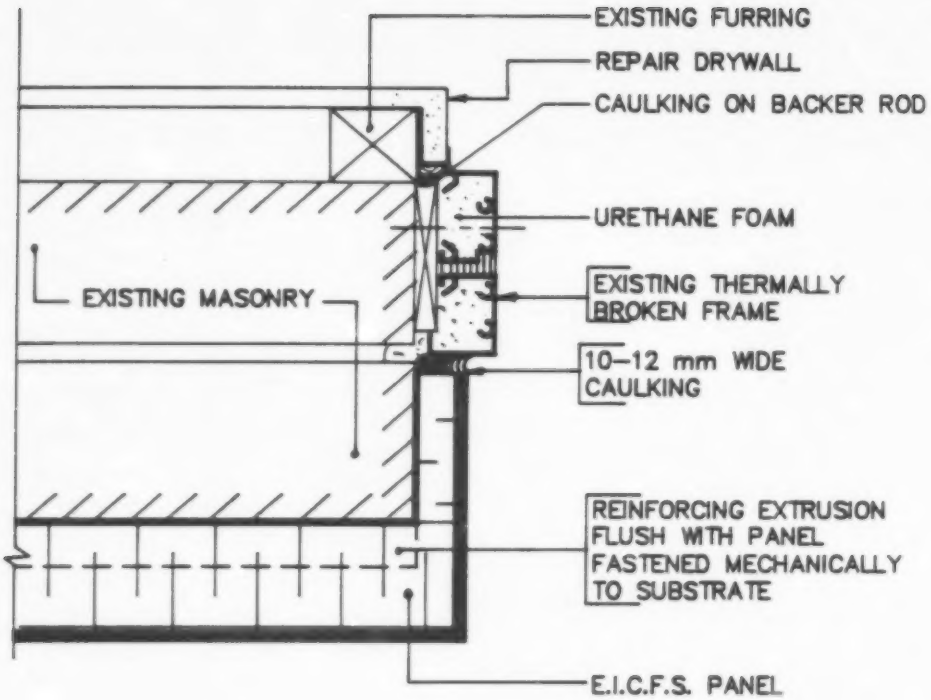
ROOF PARAPET DETAIL



DETAIL NO.4

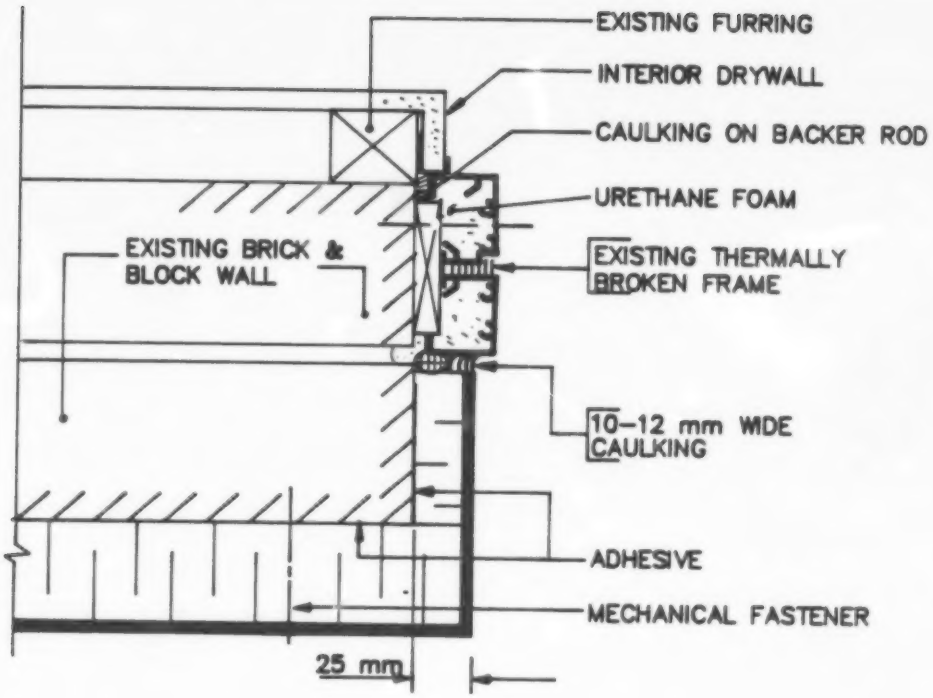
WINDOW SILL AND FIRESTOP AT FLOOR

NOTE:
HORIZONTAL PANEL JOINT BELOW FLOOR SLAB TO ALLOW INNER CAULKING



DETAIL NO.5

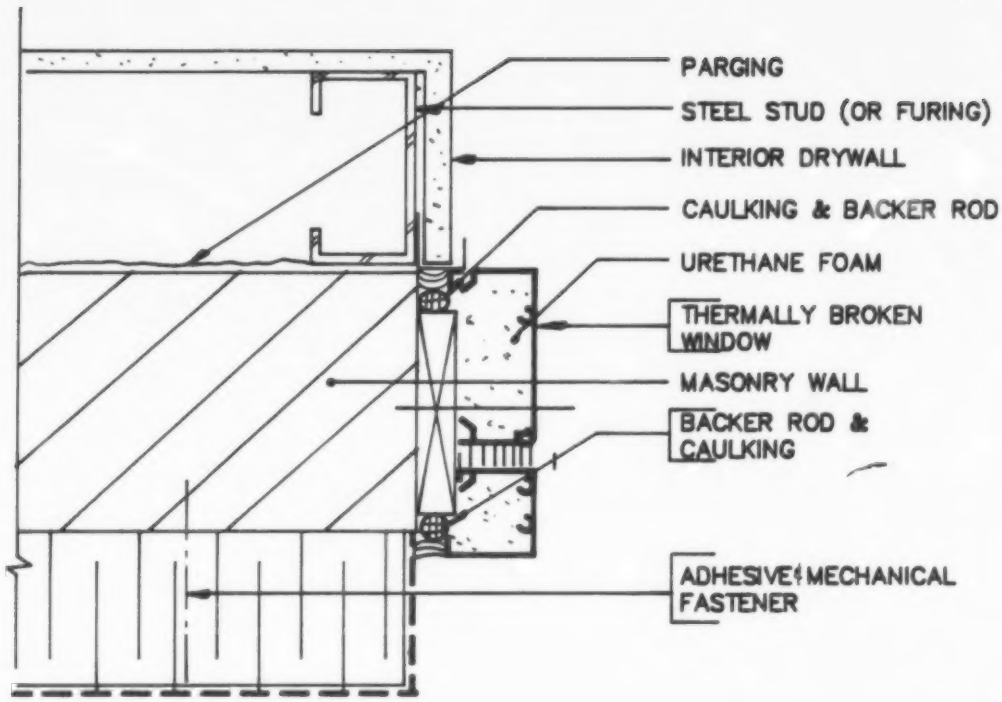
JAMB DETAIL
PREFABRICATED PANEL ON EXISTING MASONRY WALL



DETAIL NO.6

JAMB DETAIL

FIELD APPLIED E.I.C.F.S. ON EXISTING WALL



DETAIL NO.7

JAMB DETAIL

FIELD APPLIED E.I.C.F.S. OVER NEW MASONRY WALL

SECTION 3
ANALYSIS OF GLASS FIBRE REINFORCED CEMENT COMPOSITE SYSTEMS

ANALYSIS OF GLASS FIBRE REINFORCED CEMENT COMPOSITE SYSTEMS

INTRODUCTION

The trend during the recent decades has been away from solid, loadbearing structural walls to light infill or curtain walls. As the loadbearing function was taken over by steel and later reinforced concrete columns and beams, the exterior walls could become lighter. At the same time, thermal insulation became a part of the exterior wall; at first to improve thermal comfort and later to also conserve energy.

The second half of this century has also seen the development of new building materials and systems. These developments seem to have outstripped the ability of the building industry to predict the outcome of new designs and the building trades to execute the intent of the designers. As a consequence, a large part of the building stock now in existence is in need of remedial action. Such action ranges from relatively minor maintenance to major changes to the fabric in order to halt decay processes which could eventually evolve from the serviceability failure category to collapse.

One of the major developments of the recent decades has been externally applied thermal insulation which in turn is covered with a glass fibre reinforced cement composite, GFRCC. This approach was first used to rehabilitate existing masonry buildings, but more recently it has also appeared as a component of curtain walls.

GFRCC on insulation systems, like most new systems, have not always met with success. The most common problem has been cracking of the GFRCC layer. At the same time, systems have been developed which seem to have overcome such problems. To predict how well a given system will work requires specialized knowledge which goes beyond that readily available today. Even those who have a substantial amount of knowledge of the physics associated with such systems and necessary field experience may not be able to predict the outcome of a given system without undertaking a substantial amount of testing.

The purpose of the following discussion is not to provide the expertise to design GFRCC-insulation systems. It is rather to provide a discussion of the major issues which should be addressed. Hopefully this information will assist the specifier in the decision making. In the end, the applicator of the proprietary product has to provide the assurance that the system is not only sound in theory, but that the work is also properly executed.

A brief historical discussion is provided to provide a connection between traditional stucco and current GFRCC-insulation systems. Next, the properties of GFRCC, thermal insulation, and then GFRCC-insulation systems will be examined.

STUCCO ON MASONRY

Stucco on masonry is almost as old as building. It has two basic functions: to protect the wall construction from driving rain and to hide unattractive materials and workmanship. To satisfy both requirements, function and aesthetics, the stucco layer must remain uncracked and attached to the masonry substrate.

Cracking was controlled by applying the stucco in thin layers, making sure that the stucco layers were weaker than the masonry in the substrate and that each subsequent layer was more permeable than the one below it. This approach did not prevent cracking of the stucco since drying shrinkage and thermal contraction are several times greater than the capacity of the stucco to stretch. What happened was that the rigid substrate prevented the formation of a few large cracks. Once a crack formed in the stucco, it became unloaded at the crack. Load was, however, quickly transferred by shear from the substrate back into the stucco again so that the next crack formed very close to the first crack. Had the stucco layer over a building facade been free to "float", a single large crack would have formed, its width being determined by the product of the sum of all the strains leading to contraction times the length of the building facade. Attached to the wall, the sum of the micro cracks, so small that they are barely visible to the naked eye, would have approached the width of the above crack.

If a crack formed in the masonry under the stucco, such as due to settlement or thermal strain, it would also be reflected through the stucco coat.

STUCCO ON WOOD FRAME

In Western Canada, stucco on wood frame walls is quite common. Here, the major deviation from stucco on solid masonry is due to the lack of the solid masonry substrate which controlled the width of the cracks. Three things were done: the stucco was reinforced, extra reinforcement was provided at points of stress concentration, and the reinforcing fabric was nailed at close spacing to the sheathing.

The purpose of the reinforcement was to keep the crack, once opened, from becoming too large. In effect, it fulfilled, in part, the function of the rigid masonry substrate. Close nailing had

a similar effect, transferring shrinkage stress back into the uncracked stucco, thus forcing the formation of a large number of hairline cracks.

GLASS FIBRE REINFORCED CEMENT COMPOSITES

Among the recent material developments is glass fibre reinforced stucco, or more appropriately, GFRCC. The basic concept is the same as that for wire fabric reinforced stucco: to provide tensile strength to the composite and to distribute cracks so that the strain capacity of the composite is increased over that of the hardened cement matrix. Unlike traditional stucco which contains a substantial volume of sand, the glass fibres make it difficult to introduce sand into the mixture. Without the shrinkage-reducing sand, the need for glass fibres to control cracking is even greater.

In order to force the development of many small cracks, the volume fraction of glass fibre reinforcement has to be substantial. One way of increasing the fibre volume fraction of the composite is to use continuous fibres woven into a fabric. Here, the fabric is first fastened to the substrate after which a relatively thin layer of cement paste is troweled onto the fabric or where the fabric is embedded into a previously applied coat of cement paste.

The cement paste is usually polymer modified in order to improve its adhesion to the glass fibres and also to the substrate. This has another practical advantage: the cement paste matrix does not need to be continuously wet cured, it is indeed advantageous to allow the matrix to dry out so that the polymer can form a film. Water for subsequent hydration of the matrix will be provided by rain.

A major weakness of GFRCC is the loss of strength due to the chemical reaction between the alkalis in the cement and the glass. Alkali resistant glass fibres have been developed to control this reaction. Polymers added to the mix have a similar effect on protecting the fibres. Neither is, however, fully effective, leading to a substantial loss of strain and strength properties.

Where the fibres are coated with an acrylic polymer before use, the above loss of strength is controlled.

THERMAL INSULATION

A number of insula[illegible]aterials have been developed which possess properties which make it possible to use them as an insulating substrate for a GFRCC-insulation system. The basic requirement is sufficient rigidity to support the GFRCC cover. One is essentially limited to

insulation which falls into the insulating-board category. Here, the main requirement is resistance to loads normal to the board.

The insulation board normally used would fall into the semi-rigid category. This means that the board will have some resistance to shear deformation, measured by its shear modulus. How much shear resistance the board provides depends on the material it is made of and also for the given material the density of the material. At no time is it high enough to approach that of a rigid masonry substrate. This property, coupled with the thickness of insulation used, greatly influences how closely control joints have to be spaced in the GFRCC-insulation composite.

The performance of the insulation under fire conditions may also be of interest. Some jurisdictions prohibit the use of certain types of foam insulation in exterior applications under GFRCC, others limit their use to buildings which are less than three storeys high.

GFRCC ON THERMAL INSULATION

The insulation can be attached to the substrate by means of mechanical fasteners or an adhesive. The adhesive has to be such that the bond between it and the substrate as well as between the insulation remains intact during all service conditions and throughout the service life of the system. This applies equally well to mechanical fasteners. It may, however, be more difficult to determine what the conditions of the substrate are and will be in service when an adhesive is used. In view of the problems encountered with impermeable of indeed semi-impermeable membranes on porous building materials, the adhesive selection must be backed by a substantial body of experience of the conditions at hand.

The critical aspect of GFRCC-stucco system design is the matching of control joint spacing to the shear rigidity of the substrate on one hand and the maximum anticipated contraction of the GFRCC and the underlying insulation on the other.

Unless the tensile strength and strain capacities of the GFRCC are such that control joints can be left out altogether, the joints have to be so spaced that the build-up of tensile stress through shear transfer provided by the insulation and the mechanical fasteners is prevented from reaching the fracture strength of the GFRCC. By fracture strength is meant the stress required to cause fracture of the reinforcing fibres. Once this value is reached, a large, visible crack will form. Well before the fracture stress is reached, the matrix will have cracked, but these cracks are to small to be seen and may indeed heal under favourable conditions.

The spacing of control joints depends on:

1. The shear stiffness of the substrate, which is in turn determined by its thickness and shear modulus. The stiffer the insulating material, the thinner it is, the faster tensile stress will build up and the closer the control joints have to be.

2. The shear transfer provided by the mechanical fasteners.

3. Stiffness of the GFRCC. This depends mainly on the amount of glass fibres, the thickness of the GFRCC layer, and the strength properties of the matrix (water/cement ratio, degree of hydration, polymer type and volume fraction).

4. Local weather conditions, both at the time when the GFRCC hardened and extremes during its service life.